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PARASITES OF THE NEW ENGLAND COTTONTAIL (SYLVILAGUS TRANSITIONALIS) IN THE PRESENCE OF A NON-NATIVE HOST AND INVASIVE VEGETATION

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PARASITES OF THE NEW ENGLAND COTTONTAIL (*SYLVILAGUS TRANSITIONALIS)* IN THE PRESENCE OF A NON-NATIVE HOST AND INVASIVE VEGETATION

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S.L. Mello. Parasites of the New England Cottontail (*Sylvilagus transitionalis)* in the Presence of Non-Native Hosts and Invasive Vegetation, 129 pages, 4 tables, 11 figures, 2018. Journal of Mammalogy style guide used.

Imperiled New England cottontails (*Sylvilagus transitionalis,* NEC) and non-native eastern cottontails (*Sylvilagus floridanus*, EC) are sympatric in New York. This project entailed a survey of parasites in cottontail species and their environment, and examined differences between parasites of EC and NEC. There were more ticks on NEC than EC. Tick burdens of cottontails were correlated with dominant vegetation type. Sites dominated by invasive vegetation had higher tick abundances than other sites. The presence of EC at a site did not affect the tick abundances on NEC. Seven *Eimeria* species, a gastrointestinal protozoan parasite, were found in the two cottontail species, but there was no difference in the prevalence of *Eimeria* between the cottontail species. Two species of *Eimeria* that I found are known to cause coccidiosis. Population level effects of parasites on NEC should be investigated, and parasites should be considered when restoring habitat or translocating rabbits for conservation purposes.

Key words: Bayesian analysis, *Eimeria*, environmental ticks, New England cottontail, New York, parasites, *Sylvilagus transitionalis,* ticks

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CHAPTER 1: INTRODUCTION

OVERVIEW

Parasites have been found to limit host populations, cause cyclic population crashes, have negative impacts on the health and fitness of individuals, and cause mortality (Hudson et al. 1998, Clausen et al. 1980, Davis et al 1980). In particular, species with insular populations are likely to be negatively affected by parasites (Smith and Cheatum 1944). The introduction of new host species can amplify the negative effects of parasites on native hosts and increase the abundance and diversity of parasites in an area (Price et al. 1988). When a competent host species is introduced and inhabits the same area as a native host species, parasite mediated competition may occur by increasing the amount of parasites on the native host or by introducing new parasite species (Weigl 1968, Nelson and Smith 1976, Johnson et al.. 2008).

The New England cottontail (NEC; *Sylvilagus transitionalis*) is an imperiled endemic mammal of the northeastern U.S. that faces competition from an introduced competitor, but little is known about parasites of NEC. Historically common throughout New England and eastern New York, the NEC has experienced a drastic range contraction (Chapman et al. 1992, Fenderson et al. 2011). Moreover, eastern cottontails (EC; *Sylvilagus floridanus*) have expanded their range into the Northeast via introductions by humans, and are now sympatric with the NEC throughout much of the NEC range (Probert and Litvaitis 1996). Little is known about the parasite composition of the NEC or how the presence of eastern cottontails could be affecting parasite abundance or diversity. I investigated the species composition and abundance of parasites found on the NEC and in its habitat, explored the possible role of eastern cottontails on the parasite population, and developed an improved method for genetically identifying *Eimeria* species, a protozoan parasite. My research is intended to to add to growing body of knowledge on the NEC in hopes of aiding wildlife agencies in managing for this species.

NEW ENGLAND COTTONTAILS

Cottontails are true rabbits that are born naked with their eyes shut. The NEC is a member of the family Leporidae. There are four North American genera: *Sylvilagus*, *Lepus*, *Brachylagus*, and *Romerolagus.* The NEC is a medium-sized rabbit with a length of 398-439 mm and a mass of 995-1347 g (Chapman 1999). Females are slightly heavier than males (Barbour and Litvaitis 1993). Historically, the range of NEC spanned southeastern New York, southern New Hampshire, southern Maine, all of Connecticut, Massachusetts and Rhode Island and most of Vermont (Litvaitis and Jakubas 2004). The NEC most likely reached its greatest numbers and broadest distribution when there was an abundance of early successional habitat approximately between 1910 to 1960 (Litvaitis 1993). Since then, large patches of early successional habitat have decreased throughout the northeastern United States and remaining NEC populations are separated into several metapopulations (Litvaitis and Villafuerte 1996) in a contracted range. They are now found in southern Maine, southeastern New York, Connecticut, and Massachusetts and have been extirpated from Vermont (Litvaitis and Jakubas 2004). Rhode Island contains some recently reintroduced populations.

Historically, NECs occupied native shrublands occurring on sandy soils or in wetlands and regenerating forests (Litvaitis and Jakubas 2004). The latter are associated with small and large scale disturbances such as floods from beaver dams, local windstorms, hurricanes and fires. Areas on the coast frequently have more natural disturbances such as hurricanes and flooding than inland sites, leading to more habitat for NEC on the coast than inland. One of the major contributors to NEC habitat was the European settlement and clearing of forests for agriculture. When farming lands were abandoned, they matured into early successional habitat in the late 1800s and early 1900s providing a majority of NEC habitat (Litvaitis and Jakubas 2004). The abandoned farmlands have since matured into closed canopy forests and cottontail habitat has declined. Currently, NEC habitat is made up of patches of former agriculture fields, wetlands and coastal scrub with dense understory vegetation In regenerating agricultural fields and forests, NEC habitat commonly contains blackberry (*Rubus occidentalis*), a variety of young deciduous tree species like red maple (*Acer rubrum*) and birch (*Betula* spp.), and many species of exotics. Some of these exotics include honeysuckle (*Lonicera* spp.), autumn olive (*Elaeagnus umbellata*), multiflora rose (*Rosa multiflora*) and Japanese barberry (*Berberis thunbergii*) (Litvaitis and Jakubas 2004). Fields later in the successional phase used by NECs generally include birch, aspen (*Populus tremuloides*), and red maple; NECs do not seem to be attracted to conifer regeneration (Litvaitis and Jakubas 2004). Moreover, NEC prefer sites that have >50,000 stem-cover units/ha and are hesitant to move >5 m from cover (Barbour and Litvaitis 1993). Estimates of home range size of NEC vary. In Connecticut, Dalke (1937) estimated home ranges to be 0.2 to 0.7 ha in Connecticut. More recently, Goodie et al. (2003) found home ranges to be 2.2 to 7.6 ha in Connecticut.

Cottontails begin breeding at around three to four months and so can breed in the season of their birth (Rue 1965). The breeding season for cottontails in the northeast starts in mid-March and lasts through mid-September (Dalke 1942). Chapman et al. (1977) found that reproduction in male cottontails seems to be associated with the end of adverse weather. Spermatogenesis is induced in NEC by increased day length (Bissonnette and Csech 1939). Female cottontails are in anestrus during the winter, but as day length and temperature increase, hormones are secreted stimulating the growth of follicles and development of ova (Ecke 1955). The ova develop into a sub-mature stage causing the rabbit to be in heat and heat is maintained until copulation occurs (Litvaitis and Jakubus 2004). The gestation period of NEC is 28 days and the litter size ranges from 3-8 young per female (Ecke 1955). Females usually copulate immediately following parturition (Ecke 1955) and the females usually have two to three litters each year (Dalke 1942).

There are many animals that prey on NEC such as canids, felids, mustelids, raptors and certain species of snake (Chapman et al. 1982). In the northeast, known predators of NEC include bobcats (*Lynx rufus*) (Brown and Litvaitis 1995), fisher (*Martes pennant*) (Giuliano et al. 1989), red fox (*Vulpes vulpes*) (Litvaitis and Jakubus 2004), coyotes (*Canis latrans*) (Barbour and Litvaitis 1992), and domestic cats *(Felis domesticus*) (Litvaitis and Jakubus 2004). Hunting is also a cause of mortality of cottontails, but is not suspected to be a limiting factor (Litvaitis and Jakubus 2004).

Spring and summer diets of cottontail rabbits in Connecticut consisted of herbaceous plants such as clover (*Trifolium* spp.), timothy (*Phleum pratense*), and alfalfa (*Medicago sativa*) (Dalke and Sime 1941). Some other plants eaten by NEC are Canadian goldenrod (*Solidago canadensis*), raspberry (*Rubus strigosus*), highbush blueberry (*Vaccinium corymbosum*) and wild grasses (*Poaceae*) (Pringle 1960). In the fall, the rabbits' diet transitions from herbaceous plants to woody plants. During the winter, cottontail diets in Connecticut consisted of woody browse from small trees including red maple, black cherry (*Prunus serotina*), and gray birch (*Betula populifolia*) and shrubs or vines such as highbush blueberry, blackberry and black alder (*Ilex verticillata*) (Dalke and Sime 1941).

The woody vegetation used during the winter could be determined by size of the habitat patch. Barbour and Litvaitis (1993) suggested rabbit densities on small patches of habitat (<2.5

ha) in New Hampshire tended to be higher and winter forage was less abundant per rabbit; individuals consumed a higher variety of plants than cottontails on large patches (> 5 ha). Barbour and Litvaitis (1993) found that 13% of plots sampled on small patches had wood bark consumption and 2% of sample plots on large patches had bark use. Because small patches generally have higher rabbit densities, consumption of bark may have been related to food limitation.

Currently, conservation efforts focus on habitat restoration. Restoration activities include clearing mature forests to allow early-successional landscapes to develop. There are five core populations of the NEC; creating habitat that allows genetic flow among these populations could increase fitness of the population (Fuller and Tur 2012). Because there is low genetic diversity in the NEC population, conservationists have begun a captive breeding program. At Roger Williams Park Zoo in Providence, Rhode Island in 2011, there were 11 NEC young that were weaned and released into Ninigret National Wildlife Refuge; six of the surviving nine cottontails were then transferred to Patience Island, Rhode Island to try and establish a breeding colony (Fuller and Tur 2012). Since then the population on Patience Island has grown to more than 120 NEC allowing them to be relocated. In New Hampshire, twelve cottontails were introduced onto a privately owned site, but were found to have high levels of predation and mortality and are no longer there. NEC were relocated to Bellamy Wildlife Management Area in New Hampshire and have spread to another location on the same site.

EASTERN COTTONTAILS

Eastern cottontails are very similar to the NEC in appearance. Adults are generally 380-461 mm in length and weigh 825-1350 g (Saunders 1988). Females are slightly larger than males. The eastern cottontail is found throughout most of the eastern two-thirds of the United States except in northern New England (Saunders 1988). Much of this range expansion was due to the introduction of eastern cottontails by state agencies and private organizations during the early 1900s for hunting. The eastern cottontail also thrives in forest clearings and edges, meadows, farmlands, fields, residential areas and edges of swamps and marshes (Chapman et al. 1980). The eastern cottontail is much more of a habitat generalist than the NEC, which may have contributed to its range expansion. The diets of EC and NEC are similar. Their diet consists of herbaceous plants in the spring and summer and transitions into woody browse in winter. Maple, birch and raspberries are some of the plants EC browse on during the winter (Saunders 1988). In New York, the breeding season of eastern cottontails is from March until September depending on environmental conditions (Saunders 1988). Females will have multiple litters during this time and the gestation period is 28-30 days. Litter size ranges from 3-8 young. Most young are sexually mature within a year and longevity is potentially at least 10 years, but it is rare for a cottontail to survive longer than two years (Saunders 1988).

SPECIES DIFFERENCES

NEC pelage characteristics can be used reasonably well to differentiate from eastern cottontails in the hand. The anterior edges of the NEC ears have black hair and there is a black spot between their ears (Litvaitis et al. 1991). The coat is dark brown with blackwash (Litvaitis and Jakubas 2004). Eastern cottontails generally have a white spot between their ears and are slightly larger than the NEC. However, there can be other markings that make it difficult to discern the NEC from eastern cottontails. The skulls of NEC can be used to identify species. The anterior portion of the supraorbital process is short or missing and the postorbital process is long and slender (Litvaitis and Jakubas 2004). The suture between the frontal and nasals of NEC is more jagged than that of the eastern cottontail (Chapman and Litvaitis 2003). The auditory bulla of The NEC is smaller than that of the eastern cottontails (Hinderstein 1969). Genetic analysis is the most accurate way to determine species.

PARASITES

Parasites limit host populations by reducing body condition and reproductive ability. In experiments with sheep, chickens and cattle, heavy parasite burdens were linked to a decreased gain of host weight (Yuil 1964). In the United Kingdom, nematode parasites were found to affect red grouse (*Lagopus lagopus*) fecundity and caused cyclic fluctuations and crashes; populations where these parasites had been removed exhibited much fewer population fluctuations (Hudson et al. 1998). The introduction of the warble fly (*Hypoderma tarandi*) and nose bot fly (*Cephenemyia trompe*) to the native caribou (*Rangifer tarandus groenlandicus*) population of West Greenland resulted in a significant decrease in body condition and a population decline (Clausen et al. 1980). In Alaska, insect harassment and parasitism may have contributed to heavy mortality of calves during their first winter (Davis et al 1980). Yuill (1964) found that eastern cottontails infected with gastrointestinal nematodes and coccidia produced significantly less young per female than uninfected rabbits. He also found that when coccidia and gastrointestinal roundworms both infected the same host there was a greater combined effect on the body weight than when only one of the parasites infected the rabbit. Ticks have also been linked to rabbit mortality. Smith and Cheatum (1944) found that of all the parasites on the eastern cottontail population on Fisher’s Island, New York, ticks were the most abundant and were associated with infections and pathological conditions. Many rabbits exhibited pale, watery blood in the lungs and kidneys and pus pockets at tick attachment sites. One rabbit had 75 ticks embedded in the neck and was emaciated, anemic and had an abscessed lymph node. Tick bites were infected and that infection had spread from the points of attachment to nearby lymph nodes and, in one rabbit, the infection had penetrated into the myocardium. In that study, tick-induced anemia or bacterial infections were the immediate causes of mortality in cottontails. Thus, both endo- and ectoparasites can have a detrimental effect on mammal populations.

Mortality linked with parasites could be due to the strain parasites and the diseases they carry put on the immune system of their hosts. Many infectious diseases are density dependent when it comes to transmission and have adverse effects on host fitness. Body et al. (2011) manipulated population densities of roe deer (*Capreolus capreolus*) in France and analyzed the infestation by gastrointestinal strongyles and *Trichuris* species. They found that yearly levels of parasitism at the population level were positively correlated with population density of the deer. . In West Greenland, when there were high densities of caribou and apparent food limitations, colibacillosis due to *Escherichia coli* O-group 55 accounted for a high summer mortality among caribou calves (Clausen et al. 1980). In less dense populations, there was less colibacillosis and lower mortality. Woolf et al. (1993) found in a study done in southern Illinois that 32.4% of radio-marked cottontails died from tularemia, a disease that can be transmitted via arthropod vectors such as ticks. Rabbits, rodents and hares are often reservoir hosts (Mörner 1992).

Parasites may interact with other factors to affect survival and reproduction. In Finland, lack of food sources was more detrimental to field vole (*Microtus agrestis*) populations than parasites (Forbes et al 2014). Forbes et al. (2014) also found that an increase in food resources lowered the prevalence of Heligmosomoides nematodes, indicating a link between food abundance and the immune response and, more specifically, the host’s ability to defend itself against parasites. Rabbits in Connecticut with signs of malnutrition also had more species of parasites than the rabbits that did not (Clancy et al 1940). Thus, parasite infection can be a primary mortality source or can be secondary to other factors that lower resistance or impair body condition.

Parasites may be of special concern for small populations of imperiled species. Williams et al. (1988) found that a large decline in the last free-living colony of black footed ferrets was related to a parasitic pathogen in the population causing 70% mortality. Small populations are susceptible to pathogens because most individuals have not been exposed to a pathogen and there is very little acquired immunity to infection, causing high mortality (McCallum and Dobson 1995).

PARASITE MEDIATED COMPETITION

Parasite mediated competition can occur when there are two competent host species in contact with each other, and may occur without direct competition by the hosts for resources. New competition can occur if the previous hosts' ranges change and there is new contact between the host species. If the parasite were only present in one of the hosts or if the parasite evolved in one of the host species, then that host species may be less susceptible to parasitism by that parasite (Price et al 1986). Because no two hosts are identical, there generally is one host that is more susceptible to parasitism, most likely due to longer exposure to the parasite over evolutionary time. The presence of more than one host species can also cause infestations to be more severe than with a single host because parasite populations depend on host densities (Arneberg 1998, Taraschewski 2006); if one host is preferred then it could have a heavier burden than the other host. Parasites that are introduced successfully can impact native species severely if the native host is maladapted to alien parasites (Taraschewski 2006). A newly introduced host species can acquire native parasites, increase the abundance of infective stages in the environment by increasing the density of competent hosts, and increase the impact of local parasites on the native hosts (Kelly et al. 2009). During an outbreak of plague (*Yersinia pestis*) in California the woodrat (*Neotoma cinerea*) became extinct in 20 of the studied lava caves, but the mortality of deer mice (*Peromyscus maniculatus*) changed very little (Nelson and Smith 1976). Both of these species were hosts to *Yersinia* but deer mice are resistant to the pathogen and act as a reservoir host.

In North America there is evidence of parasite-mediated competition between the northern flying squirrel (*Glaucomys sabrinus*) and the southern flying squirrel (*Glaucomys volans*) through the nematode *Strongyloides robustus* (Krichbaum et al. 2010). The nematode reduces survival and productivity of the northern flying squirrel, but the southern flying squirrel seems to be unaffected (Weighl 1968). Transmission of *S. robustus* is through free-living stages in the feces of an infected individual burrowing into the skin of the host (Anderson 2000). The two host species do not need to come into direct contact with each other; they only need to occupy the same space and it can be in different time periods. The larvae of *S. robustus* are susceptible to the cold and did not persist in the range the northern flying squirrel (Pauli et al 2004). The southern flying squirrel may be more tolerant of *S. robustus* because it may have coevolved with the parasite unlike the northern squirrel. Krichbaum et al. (2010) found a lack of *S. robustus* in northern flying squirrels where there were no southern flying squirrels and found three out of four northern flying squirrels had *S. robustus* where both species coexisted.

In a study on amphibians and their platyhelminth parasite *Ribeiroia ondatrae*, Johnson et al. (2008) found an increase of competent hosts individuals in monospecific communities led to an increase in transmission and total parasite abundance. When a low-competency host was added to the system, the abundance of the parasite was significantly reduced (Johnson et al. 2008). Population densities of hosts can affect the presence of parasites and can determine their effects. In Italy, Tizzani et al. (2014) found that the overlapping distribution ranges of the introduced *S. floridanus* and the native *L. europaeus* could have aided the transmission of the nematode *Trichostrongylus affinis*. Prior to this study, *T. affinis* was only found in the natural range distribution of its host and this was the first case where it was outside that range. With the increasing population of the eastern cottontail and the decreasing population of the NEC in New York, there could be similar effects of increased transmission of parasites from the non-native eastern cottontail to the native NEC that are contributing to the population decline of the latter.

ENDOPARASITES IN COTTONTAILS

Andrews et al. (1980) found intestinal coccidia of the genus *Eimeria* were the most common protozoan parasites in eastern cottontails in the southeastern United States. In the cottontails examined, there was a lack of coccidiosis lesions; this could suggest that *Eimeria* species in cottontails are not highly pathogenic. They also found sporozoan cysts in skeletal muscle tissue that they tentatively designated *Sarcocystis* spp. The only intestinal trematode that was recovered was *Hasstileasia tricolor*. There were many occurrences of cysticerci, a larval stage, of the tapeworm *Taenia pisiformis*. They also found *Raillietina salmoni* and *Cittotaenia variabilis* frequently and with high intensity. There were several other species of internal parasites found: *Obeliscoides cuniculi, Trichostrongylus affinis, T. calcaratus, Longistraita noviberiae, Trichuris leporis, Dermatoxys veligera, Passalurus ambiguus, Dirofilaria scapiceps, Nematodirus leporis* and *Gongylonema pulchrum.* A study conducted in Connecticut found eastern cottontails had a higher percent infestation of *O. cuniculi* than The NEC in eastern and western Connecticut (Clancy et al. 1940). They also reported the highest frequency of coccidia in the cottontails, but they were unable to identify to species based on morphology alone. The endoparasites that Clancy et al. (1940) found were *O. cuniculi*, *Cittotaenia variabilis, T. pisiformis, C. variabilis,* and *P. ambiguus.* Every species found by Clancy et al. (1940) was also found by Andrews et al. (1980).

POTENTIAL ECTOPARASITES OF COTTONTAILS

In the northeastern U.S., potential ectoparasites of rabbits include ticks, fleas, lice, and bot flies. Ticks belong to the class Arachnida and are classified into three families: Argasidae (soft ticks), Ixodidae (hard ticks) and Nuttalliellidae (monotypic family) (Hopla et al 1994). Ticks feed on blood and can transmit disease agents, such as *Borrelia burgdorferi*, that cause diseases. They have three life stages: larval, nymphal and adult and require a blood meal to mature to the next life stage. Fleas feed on blood from other organisms and can cause anemia, dermatitis and pathogen transmission to hosts (Hopla et al 1994). Lice are wingless insects and are classified in the orderr Phthiraptera, with suborders Anoplura (sucking lice) and Mallophaga (chewing/biting lice) (Hopla et al 1994). Bot flies are members of the family Oestridae and feed on the host’s dead or living tissue (Hopla et al 1994).

Ticks are the best-studied mammalian ectoparasite in the northeastern U.S. due to concerns about human health. Some prevalent tick species in the range of The NEC include the American dog tick or wood tick (*Dermacentor variabilis*), the lone star tick (*Amblyomma americanum*), the brown dog tick (*Rhipicephalus sanguineus*) the rabbit tick (*Haemaphysalis* *leporispalustris*), and many *Ixodes* species: the black-legged tick or deer tick (*Ixodes scapularis*), *I. dentatus*, *I. muris, I. affinis*, the woodchuck tick (*I. cookei)*, and the squirrel tick (*I. marxi*).

The American dog tick favors high humidity and is usually found in grassy and brush-covered areas (Bishopp and Trembley 1945). The preferred host is the dog (*Canis lupus familiaris*), but immature stages engorge on small mammals such as mice. The American dog tick can transmit tularemia and is the main vector of Rocky Mountain spotted fever. Garvie et al. (1978) found the peak abundance of *D. variabilis* larvae and nymphs on small rodent populations in June and July in southwestern Nova Scotia. Adult ticks became active in May, peaked mid-May to June, and survived until August (Garvie et al. 1978).

The black-legged tick is a generalist. Adult black-legged ticks primarily feed on large mammals such as deer, but can be found on smaller mammals such as cottontails. Larval stages are active July through October or can overwinter and feed simultaneously with nymphs May through June. Nymphs are active through July. Nymphs feed on small mammals and molt into adults in September and may be active throughout the winter as long as it is above freezing. In late May, ticks emerge again and begin laying eggs. *I. scapularis* can transmit the agents of Lyme disease, anaplamosis, babeiosis and the Powassan encephalitis.

The preferred host of *R. sanguineus* is the dog, but it has been found on foxes and other canines, birds and various mammal species (Bishopp and Trembley, 1945). The larval, nymphal, and adult stages peak in July and September (Dantas-Torres 2008). *R. sanguineus* transmits Rocky Mountain spotted fever, but in the southwestern US and along the U.S.-Mexico border *R. sanguineus* is also a known vector of pathogens such as *Babesia canis* and *Ehrlichia canis* (Dantas-Torres 2008).

The rabbit tick is widely distributed throughout the United States. Rabbits are the preferred host and it is unusual to find adult stages on a different type of host (Bishopp and Trembley, 1945). Larval and nymphal stages can be found on birds. Green *et al.* (1943) found adult *H. leporispalustris* are most active during the spring, nymphs occurred throughout the year but their numbers were variable, and that larval stages were most numerous in late summer through early fall in Minnesota. The type host for *I. dentatus* is the rabbit and the tick may be a carrier for tularemia among rabbits (Bishopp and Trembley 1945). Bishopp and Trembley (1945) found the peak abundance to be April.

The lone star tick is found in wooded areas and where underbrush is dense such as near rivers (Bishopp and Trembley 1945). The lone star tick is found predominantly on ground-inhabiting birds such as wild turkey and quail, and deer; it was rarely found infesting rabbits throughout its range (Bishopp and Trembley 1945). Lone star tick can transmit *Ehrlichia chaffeensis* and *E. ewingii*, and *Francisella tularensis* (the cause of tularemia).

Tick-borne diseases are the most common vector-borne illnesses in the United States and threaten the health of humans and domestic animals (Gayle and Ringdahi 2001). The family Ixodidae is known to infest cottontail species and has been found on eastern cottontails in New York (Smith and Cheatum 1944). The most well-known tick-borne pathogen, *Borrelia burgdorferi*, causes Lyme disease and is the most common vector-borne pathogen in the United States (Gayle and Ringdahi 2001). Anderson et al. (1989) cultured spirochetes from eastern cottontails and their ticks, *I. dentatus*, belonging to *B. burgdorferi*. This suggests that *B. burgdorferi* could be found in NEC populations and the cottontails could be a source of infection for additional ticks.

THESIS GOALS AND OBJECTIVES

My goal was to provide information to managers on the potential for parasites to limit NEC populations, and for EC to affect the parasite species and burdens on NEC. The objectives of my research were to: 1) compare the abundance and species of parasites between sympatric New England and eastern cottontails, 2) compare abundance and species of parasites of NEC among sites with different proportions of eastern cottontail, 3) compare the proportion of tick species and tick abundance found on eastern cottontails and The NEC to those found in the environment, and, and 4) compare the ectoparasite species composition and abundance of shrub habitat versus grassland habitat. To meet these objectives, I proposed to test the following hypotheses:

Research Hypothesis 1): The presence of a nonnative host species will affect the parasites found on the native host species.

Test Hypotheses:

1) NEC at sites where EC are common will have a higher diversity and abundance of ticks than sites where EC are rare.
2) *Eimeria* species in NEC will be similar to those of EC where EC are common, but different in NEC that occur at sites where EC are rare.

Research Hypothesis 2) Ticks found on cottontail species will be reflective of ticks in their habitat.

Test Hypotheses:

1) Tick abundance on NECs will be correlated with tick abundance in the environment at the site level.
2) NEC tick species will reflect species in shrubland and EC tick species will reflect species in grasslands.

Chapter 2 of my thesis will focus on ticks. Chapter 3 will focus on *Eimeria*.

LITERATURE CITED

Ammazzalorso, A. D., C. P. Zolnik, T. J. Daniels, and S.-O. Kolokotronis. 2015. To beat or not to beat a tick: comparison of DNA extraction methods for ticks (*Ixodes scapularis*). PeerJ 3:e1147.

Anderson, J. F., L. A. Magnarelli, R. B. LeFebvre, T. G. Andreadis, J. B. McAninch, G.-C. Perng, and R. C. Johnson. 1989. Antigenically variable *Borrelia burgdorferi* isolated from cottontail rabbits and *Ixodes dentatus* in rural and urban areas. Journal of Clinical Microbiology 27:13–20.

Andrews, C. L., W. R. Davidson, and E. E. Provost. 1980. Endoparasites of selected populations of cottontail rabbits (*Sylvilagus floridanus*) in the Southeastern United States. Journal of Wildlife Diseases 16:395–401.

Arneberg, P., A. Skorping, B. Grenfell, and A. F. Read. 1998. Host densities as determinants of abundance in parasite communities. Proceedings: Biological Sciences 265:1283–1289.

Barbour, M. S., and J. A. Litvaitis. 1993. Niche dimensions of New England cottontails in relation to habitat patch size. Oecologia 95:321–327.

Bishopp, F. C., and H. L. Trembley. 1945. Distribution and hosts of certain north american ticks. Journal of Parasitology 31:1–54.

Bissonnette, T. H., and A. G. Csech. 1939. Modified sexual photoperiodicity in cottontail rabbits. Biological Bulletin 77:364–367.

Body, G., H. Ferté, J.-M. Gaillard, D. Delorme, F. Klein, and E. Gilot-Fromont. 2011. Population density and phenotypic attributes influence the level of nematode parasitism in roe deer. Oecologia 167:635–646.

Brown, A. L., and J. A. Litvaitis. 1995. Habitat features associated with predation of New England cottontails: What scale is appropriate? Canadian Journal of Zoology 73:1005–1011.

Chapman, J. A. 1975. *Sylvilagus transitionalis*. Mammalian Species 55:1–4.

Chapman, J. A. 1999. New England Cottontail, *Sylvilagus transitionalis*. Pages 692–693 *in*. The Smithsonian Book of North American Mammals. Second. Smithsonian Institution Press, Washington, D.C.

Chapman, J. A., A. L. Harman, and D. E. Samuel. 1977. Reproductive and physiological cycles in the cottontail complex in western Maryland and nearby West Virginia. Wildlife Monographs 56:3–73.

Chapman, J. A., J. G. Hockman, and W. R. Edwards. 1982. Cottontails (*Sylvilagus floridanus* and Allies). Pages 83–123 *in*. J. A. Chapman and G. A. Feldhamer, editors. Wild Mammals of North America. First. Johns Hopkins University Press, Baltimore, Maryland, USA.

Chapman, J. A., J. G. Hockman, and M. M. Ojeda C. 1980. *Sylvilagus floridanus*. Mammalian Species 136:1–8.

Clancy, C. F., E. Jungherr, and P. R. Sime. 1940. Internal parasites of cottontail rabbits in Connecticut. Journal of Wildlife Management 4:162–168.

Clausen, B., A. Dam, K. Elvestad, H. Krogh, and H. Thing. 1980. Summer mortality among caribou calves in West Greenland. Nordisk Veterinaermedicin 32:291–300.

Dalke, P. D., and P. R. Sime. 1941. Food habits of the eastern and New England cottontails. Journal of Wildlife Management 5:216–228.

Dantas-Torres, F. 2008. The brown dog tick, *Rhipicephalus sanguineus* (Latreille, 1806) (Acari: Ixodidae): From taxonomy to control. Veterinary Parasitology 152:173–185.

Davis, J. L., P. Valkenburg, and H. V. Reynolds. 1980. Population dynamics of Alaska's western arctic caribou herd. Proceedings of 2nd International Reindeer/Caribou Symposium, Alaska Department of Fish and Game, Fairbanks, Alaska.

Ecke, H. 1955. The reproductive cycle of the mearns cottontail in Illinois. American Midland Naturalist 53:294–311.

Fenderson, L. E., A. I. Kovach, J. A. Litvaitis, and M. K. Litvaitis. 2011. Population genetic structure and history of fragmented remnant populations of the New England cottontail (*Sylvilagus transitionalis*). Conservation Genetics 12:943–958.

Forbes, K. M., P. Stuart, T. Mappes, H. Henttonen, and O. Huitu. 2014. Food resources and intestinal parasites as limiting factors for boreal vole populations during winter. Ecology 95:3139–3148.

Fuller, S., and A. Tur. 2012. Conservation strategy for the New England cottontail (*Sylvilagus transitionalis*).

Garvie, M. B., J. A. McKiel, D. E. Sonenshine, and A. Campbell. 1978. Seasonal dynamics of American dog tick, *Dermacentor variabilis* (Say), populations in southwestern Nova Scotia. Canadian Journal of Zoology 56:28–39.

Goodie, T. G., M. A. Gregonis, and H. J. Kilpatrick. 2004. Evaluation of size, type, and distribution of habitat patches used by New England (*Sylvilagus transitionalis*) and eastern cottontails (*S. floridanus*) in Connecticut. Final Progress Report, Connecticut Department of Environmental Protection, Hartford, Connecticut.

Green, R. G., C. A. Evans, and C. L. Larson. 1943. A ten-year population study of the rabbit tick *haemaphysalis leporispalustris*. American Journal of Epidemiology 38:260–281.

Hinderstein, C. L. 1969. A comparative study of cranial characteristics of two cottontails, *Sylvilagus floridanus* and *Sylvilagus transitionalis* (Leporidae: Mammalia) in a region of sympatry. M.S. Thesis, Queens College, Flushing, New York.

Hopla, C. E., L. A. Durden, and J. E. Kierans. 1994. Ectoparasites and classification. Scientific and Technical Review of the Office International des Epizooties 13:985–1017.

Hudson, P. J., A. P. Dobson, and D. Newborn. 1998. Prevention of population cycles by parasite removal. Science 282:2256–2258.

Johnson, P. T. J., R. B. Hartson, D. J. Larson, and D. R. Sutherland. 2008. Diversity and disease: community structure drives parasite transmission and host fitness. Ecology Letters 11:1017–1026.

Kelly, D. W., R. A. Paterson, C. R. Townsend, R. Poulin, and D. M. Tompkins. 2009. Parasite spillback: A neglected concept in invasion ecology? Ecology 90:2047–2056.

Klein, D. R. 1991. Limiting factors in caribou population ecology. Rangifer 11:30–35.

Krichbaum, K., C. G. Mahan, M. A. Steele, G. Turner, and P. J. Hudson. 2010. The potential role of *Strongyloides robustus* on parasite-mediated competition between two species of flying squirrels (*glaucomys*). Journal of Wildlife Diseases 46:229–235.

Litvaitis, J. A. 1993. Response of early successional vertebrates to historic changes in land use. Conservation Biology 7:866–873.

Litvaitis, J. A., and W. Jakubas. 2004. New England cottontail (*Sylvilagus transitionalis*) assessment 2004. Maine Department of Inland Fisheries and Wildlife, Bangor, USA.

Litvaitis, J. A., and R. Villafuerte. 1996. Factors affecting the persistence of New England cottontail metapopulations: the role of habitat management. Wildlife Society Bulletin 24:686–693.

McCallum, H., and A. Dobson. 1995. Detecting disease and parasite threats to endangered species and ecosystems. Tree 10:190–194.

Mörner, T. 1992. The ecology of tularemia. Scientific and Technical Review of the Office International des Epizooties 11:1123–1130.

Nelson, B. C., and C. R. Smith. 1976. Ecological effects of a plague epizootic on the activities of rodents inhabiting caves at lava beds national monument, California. Journal of Medical Entomology 13:51–61.

Pauli, J. N., S. A. Dubay, E. M. Anderson, and S. J. Taft. 2004. *Strongyloides robustus* and the northern sympatric populations of northern (*Glaucomys sabrinus*) and southern (*G. volans*) flying squirrels. Journal of Wildlife Diseases 40:579–582.

Price, P. W., M. Westoby, and B. Rice. 1988. Parasite-mediated competition: some predictions and tests. American Naturalist 131:544–555.

Price, P. W., M. Westoby, B. Rice, P. R. Atsatt, R. S. Fritz, J. N. Thompson, and K. Mobley. 1986. Parasite mediation in ecological interactions. Annual Review of Ecology and Systematics 17:487–505.

Pringle, L. P. 1960. A study of the biology and ecology of the New England cottontail (*Sylvilagus transitionalis*) in Massachusetts. Proceedings of the North East Section of the Wildlife Society's Annual Conference. Rhode Island, Jan. 10-13, 1960, 11p, mimeographed.

Probert, B. L., and J. A. Litvaitis. 1996. Behavioral interactions between invading and endemic lagomorphs: Implications for conserving a declining species. Biological Conservation 76:289–295.

Ringdahl, E. 2001. Tick-borne diseases. American family physician 64:461–466.

Romeo, C., L. A. Wauters, N. Ferrari, P. Lanfranchi, A. Martinoli, B. Pisanu, D. G. Preatoni, and N. Saino. 2014. Macroparasite fauna of alien grey squirrels (*Sciurus carolinensis*): composition, variability and implications for native species. PLOS ONE 9:e88002.

Rue, L. L. I. 1965. Cottontail. Thomas Y. Corwell Company, New York.

Saunders, D. A. 1988. Eastern cottontail. Page 216 *in*. Adirondack mammals. Adirondack Wildlife Program, State University of New York, College of Environmental Science and Forestry.

Smith, R. H., and E. L. Cheatum. 1944. Role of ticks in decline of an insular cottontail population. Journal of Wildlife Management 8:311–317.

Taraschewski, H. 2006. Hosts and parasites as aliens. Journal of Helminthology 80:99–128.

Tizzani, P., S. Catalano, L. Rossi, P. J. Duignan, and P. G. Meneguz. 2014. Invasive species and their parasites: eastern cottontail rabbit *Sylvilagus floridanus* and *Trichostrongylus affinis* (Graybill, 1924) from Northwestern Italy. Parasitology Research 113:1301–1303.

Weigl, P. D. 1968. The distribution of the flying squirrels, *Glaucomys volans* and *G. sabrinus*; An evaluation of the competitive exclusion idea. PhD Dissertation, Duke University, Durham, North Carolina.

Williams, E. S., E. T. Thorne, M. J. Appel, and D. W. Belitsky. 1988. Canine distemper in black-footed ferrets (*Mustela nigripes*) from Wyoming. Journal of Wildlife Diseases 24:385–398.

Woolf, A., D. R. Shoemaker, and M. Cooper. 1993. Evidence of tularemia regulating a semi-isolated cottontail rabbit population. Journal of Wildlife Management 57:144–157.

Yuill, T. M. 1964. Effects of gastrointestinal parasites on cottontails. Journal of Wildlife Management 28:20–26.

CHAPTER 2: TICKS OF THE NEW ENGLAND COTTONTAIL (*SYLVILAGUS TRANSITIONALIS)* AND NEW ENGLAND COTTONTAIL HABITAT IN THE PRESENCE OF A NON-NATIVE HOST AND INVASIVE VEGETATION

ABSTRACT

Historically common throughout the northeastern United States, the New England cottontail (*Sylvilagus transitionalis*, NEC) has experienced declines throughout its range and is now only found at five geographically separated populations at the edges of its historic range. In the 1900s, eastern cottontails (*Sylvilagus floridanus*, EC) were introduced to the northeastern United States and have invaded NEC habitat. The spread of the EC created a habitat competitor for the NEC, and as both cottontails are of the same genus, potentially also introduced a second host for many ectoparasite species. The introduction of EC may have subsequently increased the abundance and diversity of parasites in the NEC range. Little is known about the parasites of the NEC and this study entails a structural survey of the species of ticks found on the two cottontail species and ticks found in their habitat in sites throughout the lower Hudson Valley of New York, and examines potential correlates of tick infestation on NEC including the role of EC. Ticks were examined on 102 NEC and 46 EC, and tick drags were conducted along transects in Spring and Fall at five sites. We found a greater abundance of ticks on NEC than EC. Species of ticks found were: *Ixodes scapularis, Dermacentor variabilis, Rhipicephalus sanguineus, and Haemaphysalis leporispalustris.* Based on tick drags, there were more ticks at sites dominated by invasive vegetation than native dominated sites. Cottontail tick burdens were related to dominant vegetation type in those sites. This study provides a baseline for tick diversity and abundance on the two cottontail species. Habitat restoration for NEC and translocation for conservation should consider the associations of ticks with vegetation types.

Key words: Invasive vegetation, New England cottontails, non-native host species, parasites, *Sylvilagus transitionalis*, ticks

INTRODUCTION

The New England cottontail (NEC; *Sylvilagus transitionalis*) is an endemic mammal of the northeastern U.S. Since the 1900s, the NEC has experienced a drastic range contraction. Once common throughout New England and eastern New York, the species is now found only in five distinct populations on the periphery of its historic range (Chapman 1975, Litvaitis and Jakubas 2004, Fenderson et al. 2011). Moreover, eastern cottontails (EC; *Sylvilagus floridanus*) have been expanding their range into the Northeast since they were introduced in the early 1900s and are now sympatric with NECs throughout much of the NEC range (Probert and Litvaitis 1996). The effect of the naturalization of EC in the range of NEC is of concern because of the potential for competition and an increased prevalence of diseases or parasites that could affect populations of NEC.

When a non-native host is introduced into an area, there is a potential for increased abundance or diversity of parasites on native hosts (Hanley et al. 1995, Hoberg et al. 2002, Tizzani et al. 2014). Wilson et al. (1985) found that an increase in the number of competent hosts increased the abundance of ticks on white-tailed deer (*Odocoileus virginianus*) in Massachusetts. An increase in the number of ticks could lead to an increase in disease in hosts. For example, on Fisher’s Island, New York, Midwestern cottontails (*Sylvilagus floridanus alacer*) that were infected with ticks in high abundance were anemic, emaciated, had infections in the kidneys, bacterial infections at the points of attachment, and some had abscessed lymph nodes indicative of a spread of infection from the abscesses at the points of attachment (Smith and Cheatum

1944). There was hyperemia and edema of the skin in regions occupied by ticks that was more severe among cottontails found dead than those cottontails that were collected by shooting. Tick-induced anemia or bacterial infections were the immediate cause of mortality in those cottontails. In addition to the direct loss of blood through tick feeding, tick saliva causes immunosuppression, which can increase the risk of mortality for those individuals that could be already immunocompromised, such as reproducing females, juveniles, or animals in the post-winter period when cottontails are at their lowest body condition (Ribeiro 1989). Pathological conditions associated with tick infestation are often worse in young hosts possibly due to decreased immune defense or a high surface area to body volume ratio (Lehmann 1993).

An additional potential stressor to NEC is the presence of invasive vegetation in much of their remaining habitat. Invasive plant species are nonnative, spread rapidly, and can become dominant vegetation in local habitats, posing a threat to native diversity (Wilcove et al. 1998). Invasive vegetation can degrade nutrient cycling and alter hydrology, and can have indirect effects on biological interactions (Mack and D'Antonio 1998, Levine et al. 2003). One of the indirect effects of invasion by non-native plants may be a change to the distribution or abundance of wildlife parasites (Ostfeld et al. 2010). Invasive vegetation species can alter abiotic features of the local microhabitat that can affect tick survival rate and transmission of pathogens (Needham and Teel 1991, Civitello et al. 2008). Williams et al. (2009) found higher blacklegged tick (*Ixodes scapularis*, BLT) densities in dense barberry (*Berberis thunbergii*) sites than in sites with controlled and no barberry in Connecticut. They found that ticks in managed barberry stands had similar prevalence of *Borrelia burgdorferi* (the causative agent of Lyme disease) to the no barberry areas. Elias et al. (2006) found black-legged tick abundances in Maine to be twice as numerous in exotic invasive infested forests, primarily characterized by Japanese barberry, than in forests dominated by native shrubs. Ticks are susceptible to desiccation and require a humidity > 85% for survival (Needham and Teel 1991). The dense canopy cover formed by many invasive vegetation species such as Japanese barberry can create microhabitats with this high relative humidity (Williams et al. 2009).

This study was initiated to investigate how an introduced competitor and invasive vegetation affect the ectoparasite abundance and diversity on an imperiled native mammal. The objectives of this study were to 1) compare tick abundance found on sympatric EC and NEC, 2) compare the proportion of different tick species on EC and NEC, 3) compare abundance and species composition of ticks on NEC among sites with different proportions of EC, 4) compare tick species composition and abundance in the habitat among sites with NEC, and 5) analyze the relationship between tick abundance in the habitat and on NEC at the site level. Our results will be used to better plan habitat management, translocation of animals, and other proposed strategies for NEC conservation.

MATERIALS AND METHODS

Study area

This study took place in the lower Hudson Valley of New York (41.453339 N, 73.704338 W), east of the Hudson River. Sites were selected based on NEC distributions estimated from fecal pellet surveys conducted by the New York State Department of Environmental Conservation (NYSDEC). Sixteen sites were selected primarily in Putnam and Dutchess Counties. Sites ranged from invasive-plant dominated shrublands to closed canopy forest and swamps with dense native or non-native understory. The climate was seasonal, with warm, humid summers and snowy winters.

Sample Collection

Single door box traps were baited with apple slices and set in areas with NEC sign or in NEC habitat. Traps were set at sites for two weeks with five nights open and two nights closed, and checked daily. Three sites were trapped per week and the sites trapped rotated every two weeks unless trapping success was unacceptably low in which case trapping continued at that site for another week. Trapping was continuous from April 2014 through October 2016. Sites where 17% of the known alive cottontails were EC were designated as “EC common” and sites with less than 17% EC were designated as “EC rare”. This 17% threshold was a natural breakpoint in our dataset, being the only cutoff at which there were adequate numbers of NECs sampled in each category for further analysis (Cheeseman 2017). All animal capture and handling procedures were approved by the State University of New York College of Environmental Science and Forestry Institutional Animal Care and Use Committee (SUNY-ESF IACUC Protocol 120801).

Mass (nearest g), pelage characteristics, and ectoparasite counts were recorded for each captured cottontail. Host species was tentatively identified in the field using morphological characteristics (Litvaitis et al. 1991). Cottontails were eartagged and a tissue sample was collected for genetic species confirmation via molecular tools (Scharine et al. 2011). Ticks visible to the naked eye were counted over the entire body of each rabbit. Hair was combed through with fingers to reveal ticks underneath the coat. Additionally, beginning in Fall of 2015 tick counts were standardized for host surface area by using a 2.54-cm^2 quadrat frame made of fiberglass window screen placed at the base of the neck where ticks tend to be abundant.

Ticks were collected from newly-captured and recaptured cottontails. Cottontails that were recaptured within three days were weighed and released without removing ticks.

Representative samples of ticks were collected from each captured individual, targeting several of each that appeared to be from different life stages and species, and those where removal would not lead to major skin lesions or tearing. Due to a concurrent cottontail survival study, not all ticks could be collected from each rabbit. Ticks were stored in 70% ethanol.

Tick drags were conducted April through June and September through October of 2016 at five sites. At four of the sites, ten 150-m transects were laid out parallel at least 50 m apart and drag-sampled (Falco and Fish 1992). Site 3 was much smaller than the other four sites and was only able to accommodate seven transects. Sites were selected based on vegetation properties: invasive vegetation dominated, native vegetation dominated, and approximately equal. A 1-m^2 white corduroy cloth attached to a 1.5-m wooden dowel was dragged along the ground and over the tops of shrubs. Every 25 m or at a change in vegetation type (e.g., grass or shrubs), the cloth was inspected for ticks. All ticks removed from the sampling area were placed in 70% ethanol to be later identified. Dominant vegetation type (native, non-native, or equal) of dragged area, distance dragged, number of ticks, and air temperature (°C) were recorded. Sessions were conducted between 1000 and 1730 hours, during favorable weather with air temperature >4 ºC and wind speed <15 km/hr. Sites were sampled April through November as weather permitted with a focus on nymph peaks (April-July) and adult peaks (September-November). Each site was sampled ten times. Ticks were morphologically identified (Clifford et al. 1961, Keirans and Clifford 1978, Yunker et al. 1986, Keirans and Litwak 1989, Durden and Keirans 1996).

Analysis

Tick quadrat counts were modeled as a function of host species and our indicator of EC prevalence (“common” and “rare”) and their interaction using mixed-effects Poisson-lognormal regression in a Bayesian framework (Kery 2010) where site was the random effect. A normally-distributed dispersion parameter was included in the log-linear predictor because model fitting suggested extra-Poisson variation. Three chains ran for 12000 iterations with a burn-in length of 1000. Uninformative flat normal priors were used for regression coefficients and an uninformative uniform prior for variance components. The proportion of individuals carrying each tick species was compared between the two rabbit species using logistic regression in a Bayesian framework (Kery 2010). Three chains ran for 1200 iterations with a burn-in length of 200. Uninformative flat normal priors were used for regression coefficients.

Tick abundance from drags was compared among four vegetation types and over time within two seasons using mixed effects Poisson log-normal regression in a Bayesian framework (Kery 2010) with site as a random effect. The distance of the tick drags was used as an offset. The model was run with 3 chains for 4000 iterations with a burn in length of 1000. Uninformative flat normal priors were used for regression coefficients and an uninformative uniform prior for variance components.

All analyses were conducted in WinBUGS (Lunn et al. 2000) called using the R2WinBUGS package (Sturtz et al. 2005) in R (R Core Team 2013). The strength of the relationships between mean tick abundance at a site (determined from tick drags) and mean tick abundance on NEC (determined from whole body tick counts) was determined using Spearman's correlation coefficient.

RESULTS

Tick abundance on cottontails

Of 179 NEC captures, 123 individuals were found to host ticks. There were 100 EC captured and 72 were found to host ticks. The prevalence of individuals with ticks was similar between the two cottontail species: NEC = 68.0%, EC = 72.0%. NECs had greater tick counts per quadrat at the base of the neck than eastern cottontails (Figure 2.1). The mean number of ticks on NEC was higher in Spring than in Fall (Figure 2.2). There was no effect of EC relative prevalence on the quadrat tick counts of NEC (Figure 2.3). During our field season, several juvenile cottontails died in our trap; many of them were infested with over 70 ticks. Many adult cottontails had whole body tick counts greater than 30 ticks.

Five tick species were found on the cottontails: black-legged tick (*Ixodes scapularis*), *I. dentatus*, rabbit tick (*Haemaphysalis leporispalustris*), American dog tick (*Dermacentor variabilis*), and the brown dog tick (*Rhipicephalus sanguineus*). A higher proportion of EC than NEC was infested with the rabbit tick (Figure 2.4). There was no difference in prevalence of the other four tick species between the two cottontails.

Environmental ticks

Only black-legged ticks were collected during tick drags. There were more ticks in the grass zones than in the shrub zones (Figure 2.5). Tick abundance was higher in Fall than in Spring, increased over time in Spring, and decreased over the Fall, but based on overlap of credible intervals there was no difference among vegetation zones within periods (Figure 2.6). The invasive dominated site had more ticks than the mixed and native dominated sites (Figure 2.7). The native site had the lowest abundance of ticks. There was a strong correlation between the mean tick abundance on drags, with vegetation types pooled, and mean tick abundance on rabbits (Figure 2.8), with cottontails at the invasive-dominated site hosting the greatest number of ticks and cottontails at the native-dominated site hosting the least number.

DISCUSSION

The higher abundance of ticks on NEC than EC could result in more negative effects such as anemia, emaciation, exsanguination, or infection in the native cottontail than its non-native competitor (Jellison and Kohls 1938). Thus ticks could contribute to lower body condition and lower overall fitness of NEC than EC (Lightfoot and Norval 1981, Lehmann 1993). Smith and Cheatum (1944) found that an adult cottontail infested with 40 or more ticks died and cottontails infested with ticks exhibited signs of anemia. The number of ticks found on some juveniles was much higher than the 40-tick threshold found to be lethal for adults, and could be linked to the juvenile mortalities. The high tick burdens on NEC in early Spring when they are nutritionally stressed and on juvenile cottontails are of concern. Stressed rabbits and young rabbits are susceptible to anemia, emaciation, and infections due to tick infestation (Ould and Welch 1980, Scott 1988, Brown et al. 2003). Rabbits are also susceptible during reproduction or when there are environmental stressors. High levels of parasitism will compound the effects of stress thus increasing the chance of mortality.

Of the five species of ticks found on NEC, black-legged ticks were the most prevalent. Black-legged ticks are known vectors of *Borrelia burgdorferi*, the causative agent of Lyme disease. EC and NEC were equally likely to host at least one black-legged tick, but with fewer ticks per individual EC may have had less exposure to the disease. A comparison of the prevalence of the disease in the two cottontail species would be valuable.

Because of the similarity in physical characteristics between the two cottontail species, it is unlikely that the morphological traits of NEC or EC are the determining factor for the difference in tick abundance and species composition found on the two hosts. Habitat has been demonstrated as a factor in tick abundance on host species (Jellison and Kohls 1938, Ribeiro 1989, Adler et al. 1992, Lindström and Jaenson 2003). Habitat selection is known to differ between the two cottontail species, which could explain the difference in tick abundance between them (Cheeseman 2017). NEC select for dense shrub areas while EC select for early successional shrubland and grassland (Chapman et al. 1980, Litvaitis and Jakubas 2004). The selection of dense shrub in invasive dominated sites could lead to an increase in the amount of ticks found on the cottontails as ticks are known to occur in greater numbers in invasive shrubs than native shrubs (Adler et al. 1992, Lindsay et al. 1999, Randolph 2001, Lindström and Jaenson 2003). Edge vegetation also harbors high numbers of ticks (Kgoroba 1979). When EC are common in a habitat patch, NEC are more likely to select for invasive shrubs such as Japanese barberry than when EC are rare (Cheeseman 2017). This increased use of invasive vegetation could increase NEC exposure to ticks and increase their body burden. The higher prevalence of the rabbit tick on EC compared to NEC is likely linked to habitat selection as well. Rabbit ticks select for shorter vegetation that is generally found in grasslands (Camin and Drenner 1978), which provides habitat for EC.

The seasonal trends in tick abundance were similar to other studies (Philip 1937, Kgoroba 1979, Clark et al. 1998, Ostfeld et al. 2010). Tick drags were started once the weather was warm enough for ticks to begin to emerge. Tick emergence peaks in early Spring when conditions are moist, and decreases as the weather becomes warmer and drier (Needham and Teel 1991, Ostfeld et al. 1996, Clark et al. 1998). In Fall, dragging was done when the weather reached the ideal temperature and humidity for emergence for adult ticks. Nymphs are more susceptible to desiccation and may not have emerged until later in Fall explaining the increasing trend of ticks in the environment over that period (Ostfeld et al. 1996, Clark et al. 1998).

Tick counts were higher in Fall than Spring potentially because the Winter before our tick drag season of 2015-2016 was mild and there was an early Spring. Warm Winter and early Spring conditions cause larva and nymphs to quest early in the year and allow their main host, the white footed mouse (*Peromyscus leucopus*), to better survive Winter, thus providing a greater host population throughout the year (Randolph and Storey 1999, Randolph 2001). Larvae and nymphs may have been questing earlier than anticipated due to the early Spring and may not have been collected. Also, tick dragging is more likely to collect questing adult ticks than younger stages in shrublands because it does not sample the leaf litter underneath the shrubs where nymphs and larvae would be found (Rulison et al. 2013). The greater abundance of adult ticks in Fall than in Spring may explain the greater overall abundance of ticks I observed in Fall. Moreover, larval ticks have a highly clumped distribution and are rarely found to disperse more than 3 m (Daniels and Fish 1990). Larval tick collections would be sparse if the drags missed one of these clumped populations. Less distance between transects or CO_2 trapping to attract ticks that were not along transects can be used to corrected for clumped distribution (Gherman et al. 2012). Larva mature during Summer and disperse farther as nymphs, which could increase the likelihood they will be collected on transects as nymphs in Fall (Ostfeld et al. 2010).

Although the tick species obtained during drags were not representative of the species found on the cottontails, the correlation in site-level average tick numbers between vegetation and cottontails was high, so tick drags may provide a reasonable index to tick infestation on cottontails. Sites dominated by invasive plants are likely to harbor more ticks on vegetation and to have higher infestation on cottontails than sites with more native vegetation. The invasive vegetation at our sites was composed primarily of Japanese barberry, Japanese honeysuckle (*Lonicera japonica*), multiflora rose (*Rosa multiflora*) and oriental bittersweet (*Celastrus orbiculatus*). These species form thick canopies that may be attractive to cottontails and other species as cover, and this concentration of hosts could lead to increased tick abundance. Also, unlike some native vegetation, plants such as Japanese barberry are not readily consumed by herbivores allowing them to expand over an entire patch (Silander and Klepeis 1999). This dense canopy cover allows ticks to quest for longer periods of time increasing their ability to mature and reproduce (Needham and Teel 1991, Adler et al. 1992, Williams et al. 2009).

Management of habitat for native mammals should aim to avoid fostering high tick abundance. Managing to reduce invasive vegetation and therefore the tick population could decrease exposure NEC to ticks and tick-borne diseases. Moreover, when translocating cottontails among sites, abundance of tick in the environment and tick infestation of translocated rabbits should be examined, as well as the potential for competitors such as EC to restrict the translocated rabbits to vegetation types that harbor high numbers of ticks. Introducing cottontails to an area where tick abundances are high may reduce the ability of stressed cottontails to survive until reproduction.

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LITERATURE CITED

Adler, G. H., S. R. Telford, M. L. Wilson, and A. Spielman. 1992. Vegetation structure influences the burden of immature Ixodes dammini on its main host, *Peromyscus leucopus*. Parasitology 105 (Pt 1):105–110.

Brown, M. J. F., R. Schmid-Hempel, and P. Schmid-Hempel. 2003. Strong context-dependent virulence in a host–parasite system: reconciling genetic evidence with theory. Journal of Animal Ecology 72:994–1002.

Camin, J. H., and R. W. Drenner. 1978. Climbing behavior and host-finding of larval rabbit ticks (*Haemaphysalis leporispalustris*). Journal of Parasitology 64:905–909.

Chapman, J. A. 1975. *Sylvilagus transitionalis*. Mammalian Species 1–4.

Chapman, J. A., J. G. Hockman, and M. M. Ojeda C. 1980. *Sylvilagus floridanus*. Mammalian Species 136:1–8.

Cheeseman, A. E. 2017. Factors limiting recovery of the New England cottontail in New York. Dissertation, State University of New York College of Environmental Science and Forestry, Syracuse, NY.

Civitello, D. J., S. L. Flory, and K. Clay. 2008. Exotic grass invasion reduces survival of *Amblyomma americanum* and *Dermacentor variabilis* ticks (Acari: Ixodidae). Journal of Medical Entomology 45:867–872.

Clark, K. L., J. H. Oliver, D. B. McKechnie, and D. C. Williams. 1998. Distribution, abundance, and seasonal activities of ticks collected from rodents and vegetation in South Carolina. Journal of Vector Ecology: Journal of the Society for Vector Ecology 23:89–105.

Clifford, C. M., G. Anastos, and A. Elbl. 1961. The larval ixodid ticks of the eastern United States (Acarina-Ixodidae). Entomological Society of America.

Daniels, T. J., and D. Fish. 1990. Spatial distribution and dispersal of unfed larval *Ixodes dammini* (Acari: Ixodidae) in southern New York. Environmental Entomology 19:1029–1033.

Durden, L. A., and J. E. Keirans. 1996. Nymphs of the genus ixodes (Acari: Ixodidae) of the United States: taxonomy, identification key, distribution, hosts, and medical/veterinary importance. Entomological Society of America.

Elias, S. P., C. B. Lubelczyk, P. W. Rand, E. H. Lacombe, M. S. Holman, and R. P. Smith. 2006. Deer browse resistant exotic-invasive understory: an indicator of elevated human risk of exposure to Ixodes scapularis (Acari: Ixodidae) in southern coastal Maine woodlands. Journal of Medical Entomology 43:1142–1152.

Falco, R. C., and D. Fish. 1992. A comparison of methods for sampling the deer tick,*Ixodes dammini*, in a Lyme disease endemic area. Experimental & Applied Acarology 14:165–173.

Fenderson, L. E., A. I. Kovach, J. A. Litvaitis, and M. K. Litvaitis. 2011. Population genetic structure and history of fragmented remnant populations of the New England cottontail (*Sylvilagus transitionalis*). Conservation Genetics 12:943–958.

Gherman, C. M., A. D. Mihalca, M. O. Dumitrache, A. Györke, I. Oroian, M. Sandor, and V. Cozma. 2012. CO2 flagging - an improved method for the collection of questing ticks. Parasites & Vectors 5:125.

Hanley, K. A., D. M. Vollmer, and T. J. Case. 1995. The distribution and prevalence of helminths, coccidia and blood parasites in two competing species of gecko: implications for apparent competition. Oecologia 102:220–229.

Hoberg, E. P., S. J. Kutz, J. Nagy, E. Jenkins, B. Elkin, M. Branigan, and D. Cooley. 2002. *Protostrongylus stilesi* (Nematoda: Protostrongylidae): ecological isolation and putative host-switching between dall’s sheep and muskoxen in a contact zone. Comparative Parasitology 69:1–9.

Jellison, W. L., and G. M. Kohls. 1938. Tick-host anemia: a secondary anemia induced by *Dermacentor andersoni* stiles. Journal of Parasitology 24:143–154.

Keirans, J. E., and C. M. Clifford. 1978. The genus Ixodes in the United States: a scanning electron microscope study and key to the adults. Journal of Medical Entomology 15:1–38.

Keirans, J. E., and T. R. Litwak. 1989. Pictorial key to the adults of hard ticks, family Ixodidae (Ixodida: Ixodoidea), east of the Mississippi River. Journal of Medical Entomology 26:435–448.

Kery, M. 2010. Introduction to WinBUGS for Ecologists: Bayesian approach to regression, ANOVA, mixed models and related analyses. 1 edition. Academic Press, Amsterdam ; Boston.

Kgoroba, K. 1979. A study of the seasonal population dynamics of the ticks *Dermacentor variabilis* (Say) and *Haemaphysalis leporispalustris* (Packard) in a marshland habitat. Master of Science, University of Manitoba, Winnipeg, Manitoba.

Lehmann, T. 1993. Ectoparasites: direct impact on host fitness. Parasitology today 9:8–13.

Levine, J. M., M. Vilà, C. M. D. Antonio, J. S. Dukes, K. Grigulis, and S. Lavorel. 2003. Mechanisms underlying the impacts of exotic plant invasions. Proceedings of the Royal Society of London B: Biological Sciences 270:775–781.

Lightfoot, C. J., and R. A. I. Norval. 1981. Tick problems in wildlife in Zimbabwe. 1. The effects of tick parasitism on wild ungulates. South African Journal of Wildlife Research 11:41–45.

Lindsay, L. R., S. W. Mathison, I. K. Barker, S. A. McEwen, and G. A. Surgeoner. 1999. Abundance of *Ixodes scapularis* (Acari: Ixodidae) larvae and nymphs in relation to host density and habitat on Long Point, Ontario. Journal of medical entomology 36:243–254.

Lindström, A., and T. G. T. Jaenson. 2003. Distribution of the common tick, *Ixodes ricinus* (Acari: Ixodidae), in different vegetation types in southern Sweden. Journal of Medical Entomology 40:375–378.

Litvaitis, J. A., and W. Jakubas. 2004. New England cottontail (*Sylvilagus transitionalis*) assessment 2004. Maine Department of Inland Fisheries and Wildlife, Bangor, USA.

Litvaitis, J. A., D. L. Verbyla, and M. K. Litvaitis. 1991. A field method to differentiate New England and eastern cottontails. Transactions of the Northeast Section of the Wildlife Society 48:11–14.

Lunn, D. J., A. Thomas, N. Best, and D. Spiegelhalter. 2000. WinBUGS — a Bayesian modelling framework: concepts, structure, and extensibility. Statistics and Computing 10:325–337.

Mack, M. C., and C. M. D'Antonio. 1998. Impacts of biological invasions on disturbance regimes. Trends in Ecology & Evolution 13:195–198.

Needham, G. R., and P. D. Teel. 1991. Off-host physiological ecology of ixodid ticks. Annual review of entomology 36:659–681.

Ostfeld, R. S., K. R. Hazler, and O. M. Cepeda. 1996. Temporal and spatial dynamics of *Ixodes scapularis* (Acari: Ixodidae) in a rural landscape. Journal of Medical Entomology 33:90–95.

Ostfeld, R. S., F. Keesing, and V. T. Eviner. 2010. Infectious disease ecology: effects of ecosystems on disease and of disease on ecosystems. Princeton University Press.

Ould, P., and H. E. Welch. 1980. The effect of stress on the parasitism of mallard ducklings by *Echinuria uncinata* (Nematoda: Spirurida). Canadian Journal of Zoology 58:228–234.

Philip, C. B. 1937. Six years' intensive observation on the seasonal prevalence of a tick population in western Montana: a preliminary summary. Public Health Reports (1896-1970) 52:16–22.

Probert, B. L., and J. A. Litvaitis. 1996. Behavioral interactions between invading and endemic lagomorphs: Implications for conserving a declining species. Biological Conservation 76:289–295.

R Core Team. 2013. R: a language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.

Randolph, S. E. 2001. The shifting landscape of tick-borne zoonoses: tick-borne encephalitis and Lyme borreliosis in Europe. Philosophical Transactions of the Royal Society of London B: Biological Sciences 356:1045–1056.

Randolph, S. E., and K. Storey. 1999. Impact of microclimate on immature tick-rodent host interactions (Acari: Ixodidae): implications for parasite transmission. Journal of Medical Entomology 36:741–748.

Ribeiro, J. M. C. 1989. Role of saliva in tick/host interactions. Experimental & Applied Acarology 7:15–20.

Rulison, E. L., I. Kuczaj, G. Pang, G. J. Hickling, J. I. Tsao, and H. S. Ginsberg. 2013. Flagging versus dragging as sampling methods for nymphal *Ixodes scapularis* (Acari: Ixodidae). Journal of Vector Ecology 38:163–167.

Scharine, P. D., C. K. Nielsen, E. M. Schauber, L. Rubert, and J. C. Crawford. 2011. Occupancy, detection, and habitat associations of sympatric lagomorphs in early-successional bottomland forests. Journal of Mammalogy 92:880–890.

Scott, M. E. 1988. The impact of infection and disease on animal populations: implications for conservation biology. Conservation Biology 2:40–56.

Silander, J. A., and D. M. Klepeis. 1999. The invasion ecology of Japanese barberry (*Berberis thunbergii*) in the New England landscape. Biological Invasions 1:189–201.

Smith, R. H., and E. L. Cheatum. 1944. Role of ticks in decline of an insular cottontail population. Journal of Wildlife Management 8:311–317.

Sturtz, S., U. Ligges, and A. Gelman. 2005. R2WinBUGS: A package for running WinBUGS from R. R. Journal of Statistical Software 12:1–16.

Tizzani, P., S. Catalano, L. Rossi, P. J. Duignan, and P. G. Meneguz. 2014. Invasive species and their parasites: eastern cottontail rabbit *Sylvilagus floridanus* and *Trichostrongylus affinis* (Graybill, 1924) from Northwestern Italy. Parasitology Research 113:1301–1303.

Wilcove, D. S., D. Rothstein, J. Dubow, A. Phillips, and E. Losos. 1998. Quantifying threats to imperiled species in the United States. BioScience 48:607–615.

Williams, S. C., J. S. Ward, T. E. Worthley, and K. C. Stafford. 2009. Managing Japanese barberry (Ranunculales: Berberidaceae) infestations reduces blacklegged tick (Acari: Ixodidae) abundance and infection prevalence with *Borrelia burgdorferi* (Spirochaetales: Spirochaetaceae). Environmental Entomology 38:977–984.

Wilson, M. L., G. H. Adler, and A. Spielman. 1985. Correlation between abundance of deer and that of the deer tick, *Ixodes dammini* (Acari: Ixodidae). Annals of the Entomological Society of America 78:172–176.

Yunker, C. E., J. E. Keirans, C. M. Clifford, and E. R. Easton. 1986. Dermacentor ticks (Acari: Ixodoidea: Ixodidae) of the New World: a scanning electron microscope atlas. Proceedings of the Entomological Society of Washington (USA).

Table 2.1 List of sites with characteristics of the vegetation and presence of eastern cottontails (EC) over two years in New York, 2015-2017.

Site	Dominant plant type	EC Presence	
		2015	2016
1	Native shrub	Rare	Rare
2	Mixed shrub	Common	Common
3	Swamp with dense native shrub	Rare	Rare
4	Large patches of barberry surrounding grass fields	Common	Common
5	Native shrub	Common	n/a
6	Invasive shrub, predominately barberry	Common	Common
7	Mixed shrub	Common	Common
8	Invasive shrub around large grass field	Rare	Rare
12GT	Mixed shrub	Common	Common
12N	Mixed shrub	Common	Rare
13B	Invasive shrub	Common	Common
18	Swamp with dense native shrub	Rare	n/a
19	Swamp with dense invasive shrub	Common	Rare
20	Mixed shrub with large patches of barberry	n/a	Rare

n/a = did not sample

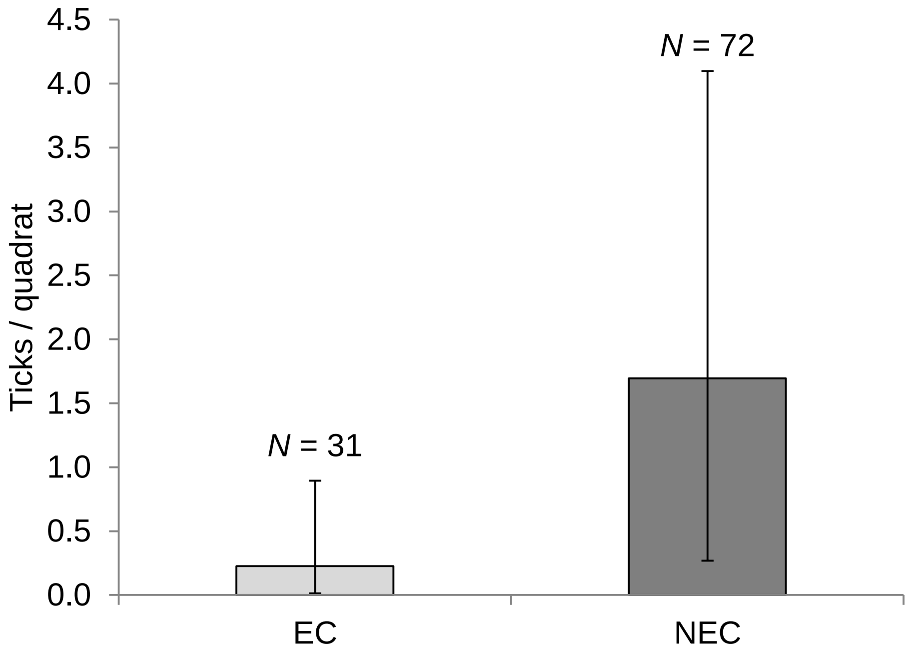

Figure 2.1. Mean number of ticks per quadrat at the base of the neck of New England cottontails (NEC) and eastern cottontails (EC) in New York, 2015-2017. Sample sizes (*N*) and 95% credible intervals are shown.

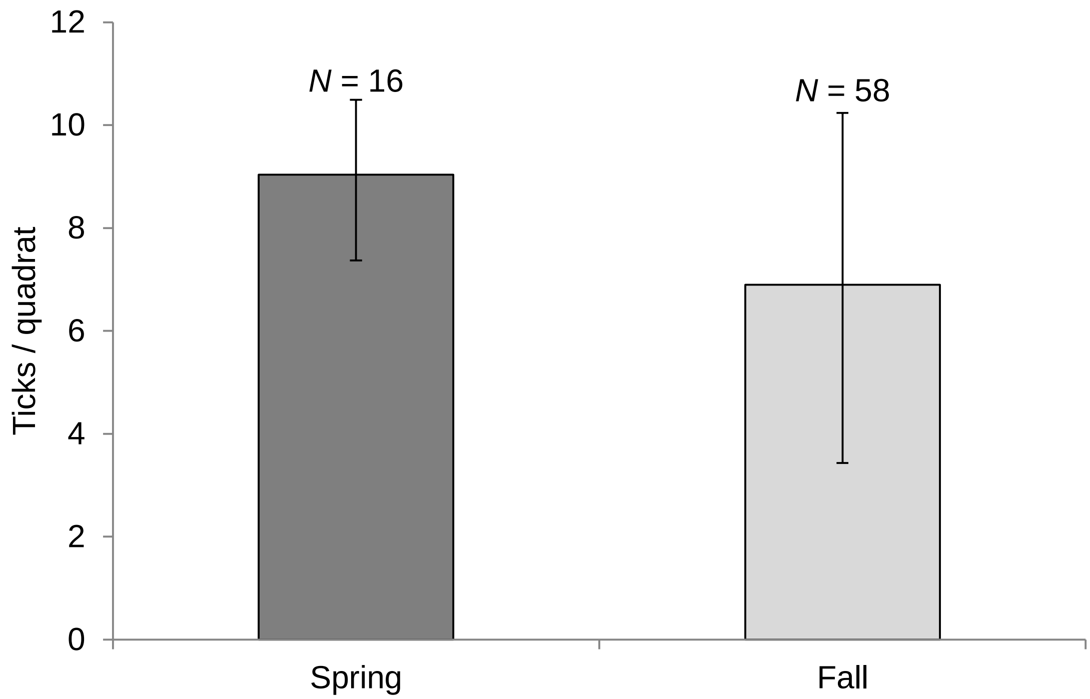

Figure 2.2. Mean number of ticks per quadrat at the base of the neck of New England cottontails in New York in Spring and Fall, 2015-2017. Sample sizes (*N*) and 95% credible intervals are shown.

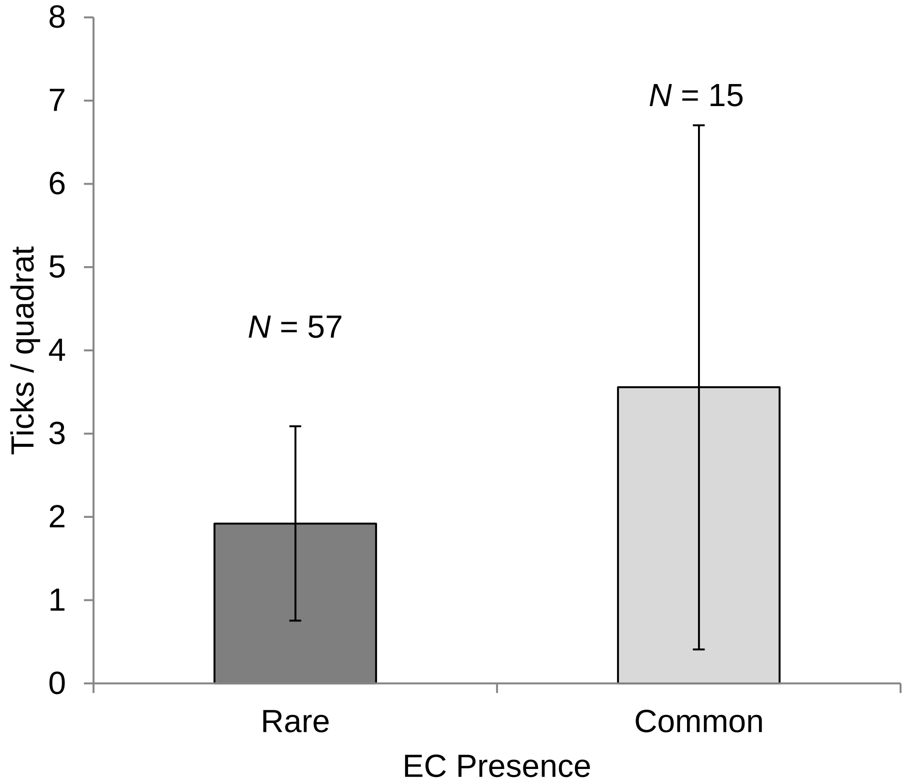

Figure 2.3. Mean ticks per quadrat on New England cottontails (NEC) where eastern cottontail (EC) were rare (comprised <17% of known alive cottontails at a site) or common in New York, 2015-2017. Sample sizes (*N*) and 95% credible intervals are shown.

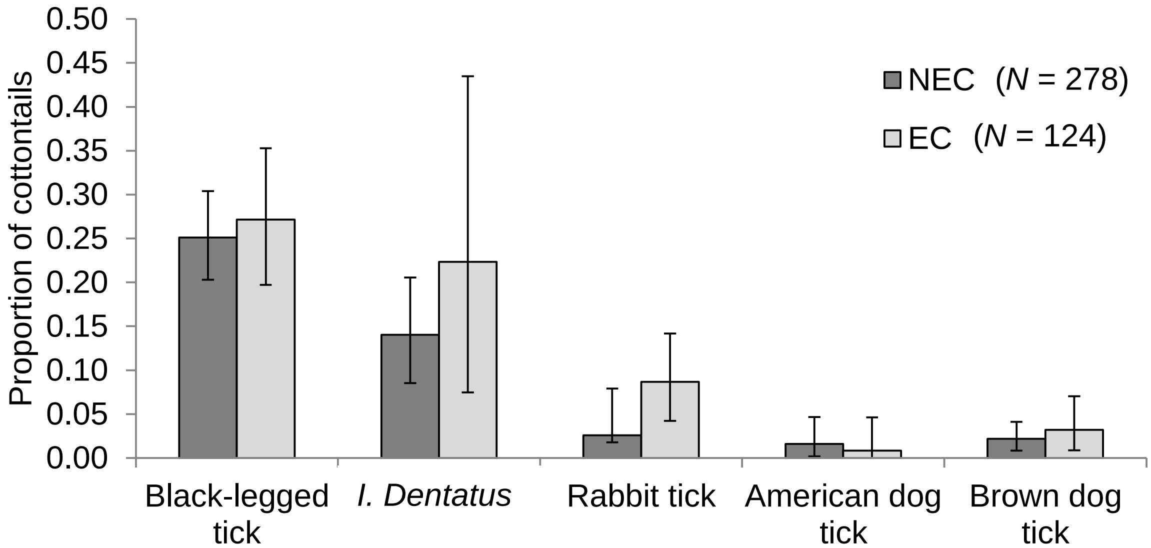

Figure 2.4. Prevalence of five tick species on New England cottontails (NEC) and eastern cottontails (EC) in New York, 2015-2017. Sample sizes (*N*) and 95% credible intervals are shown.

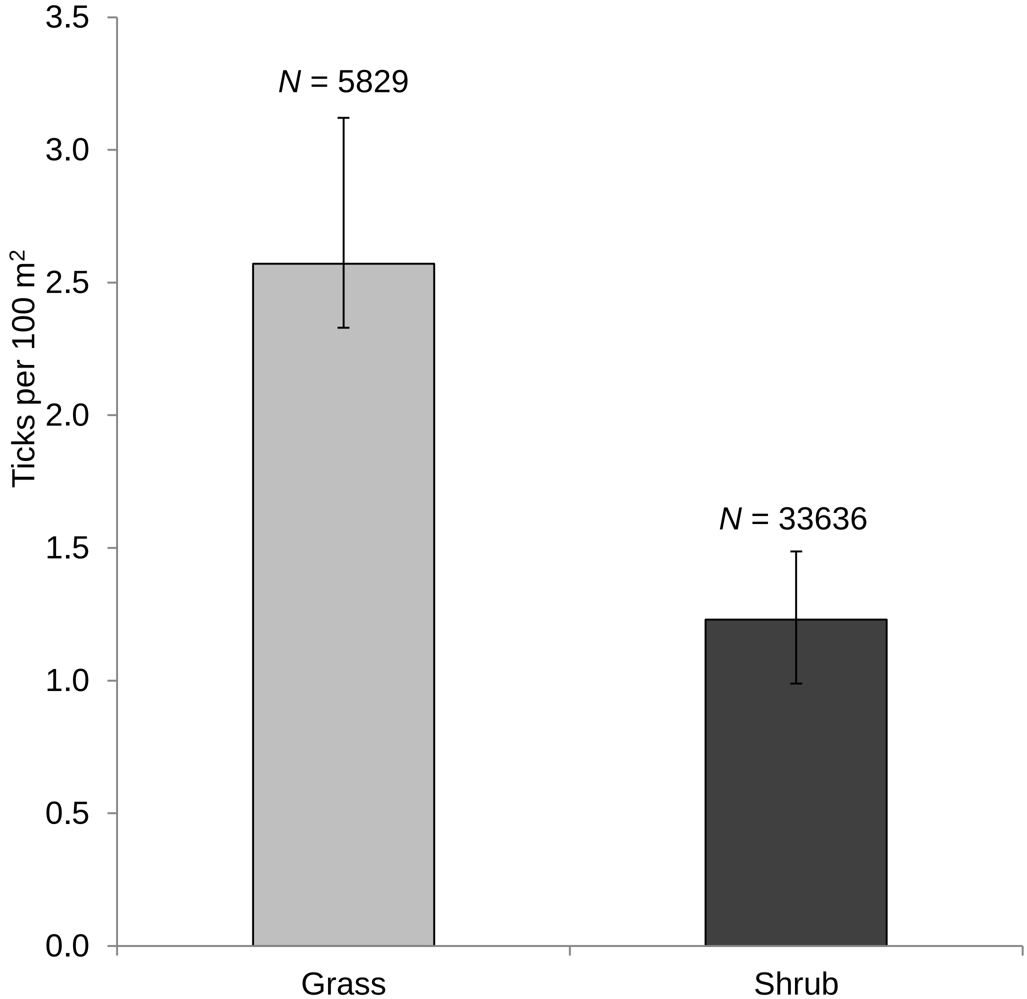

Figure 2.5 Mean number of ticks in grassland and shrubland at sites with New England cottontails (NEC) in New York, 2015-2017. The number of meters dragged (*N*) and 95% credible intervals are shown.

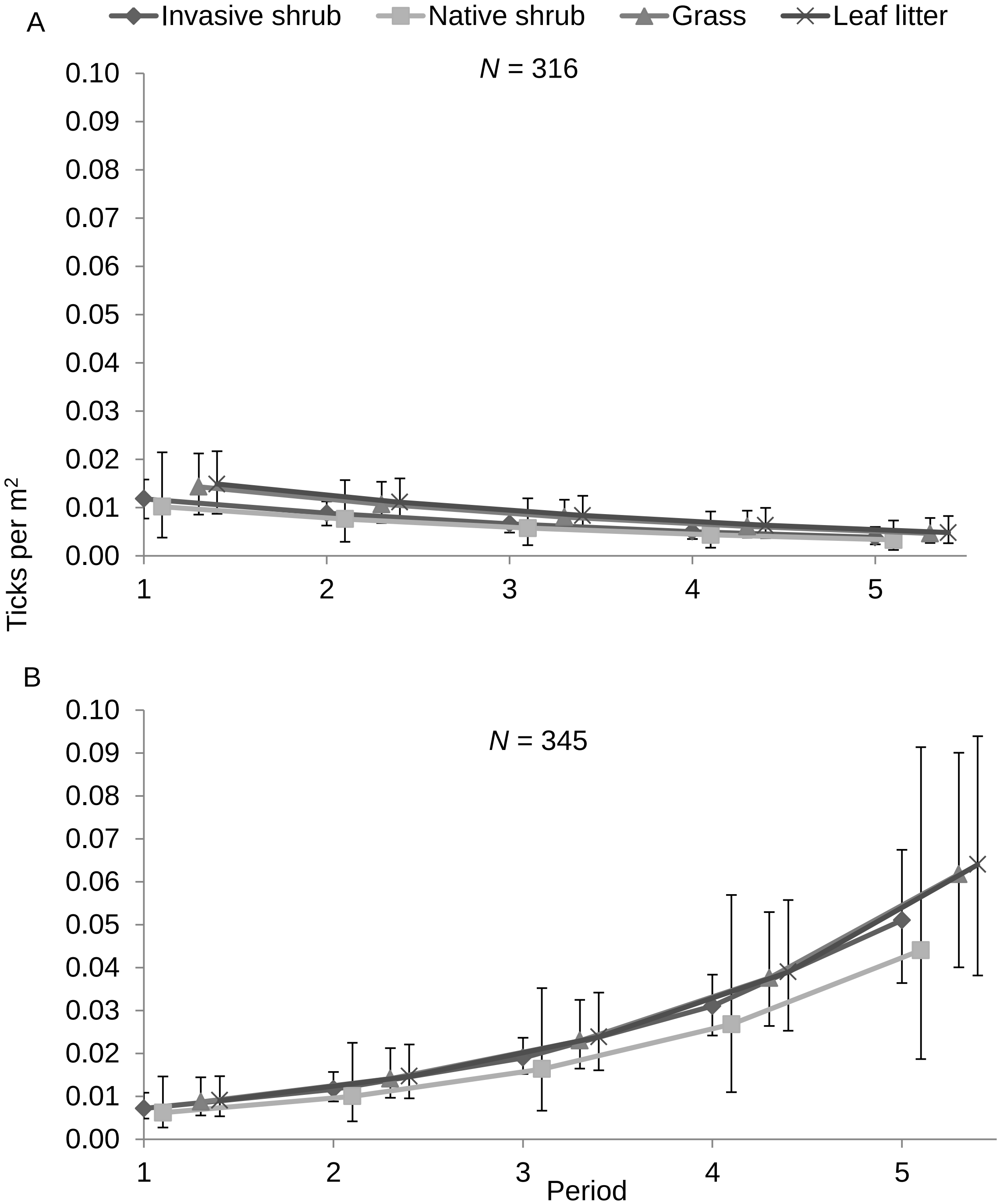

Figure 2.6. Mean number of ticks / m^2 in the five sampling sessions in the (A) Spring and (B) Fall season in four vegetation categories in New England cottontail sites in New York, 2015-2017. Number of transects dragged in each season (*N*) and 95% credible intervals are shown.

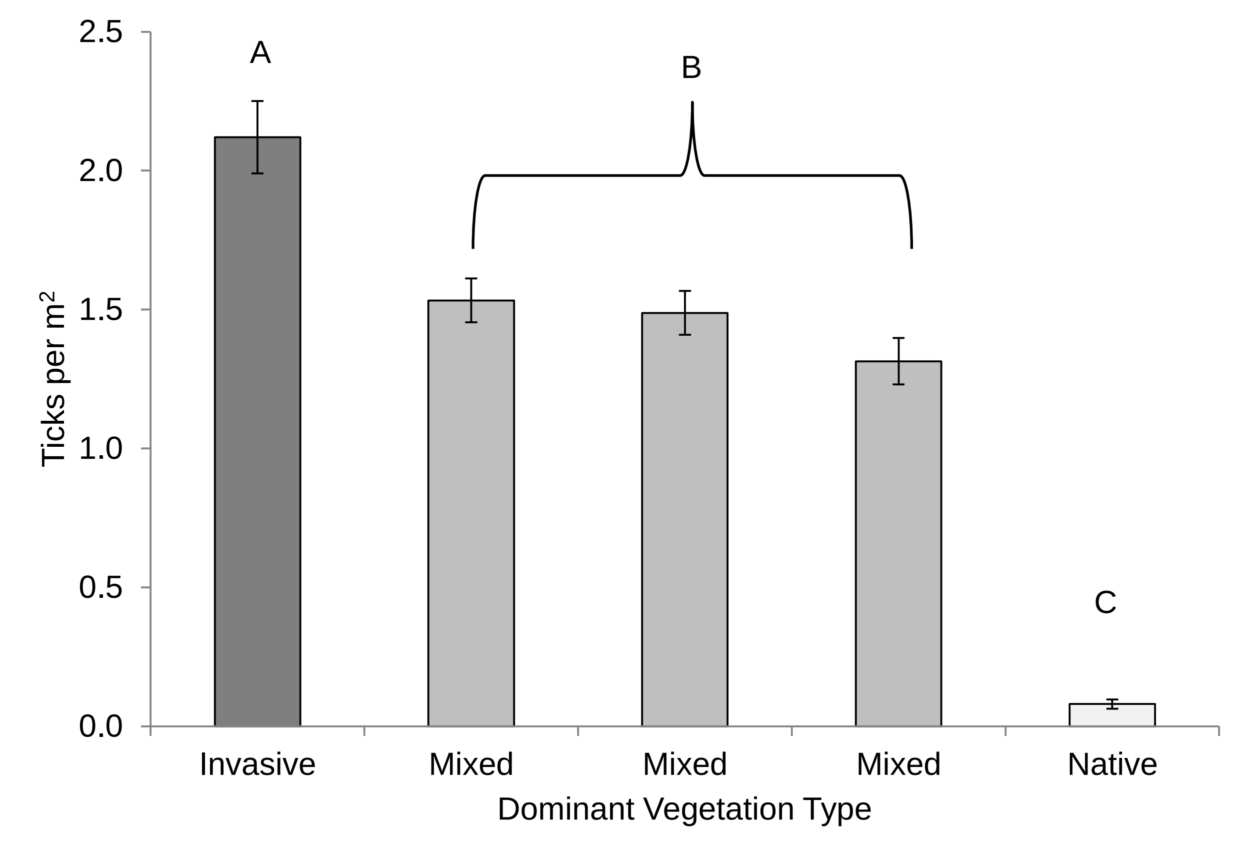

Figure 2.7 Mean abundance of ticks in the habitat at five sites in New York, 2015-2017 (ANOVA, $F_{\mathrm{dfn,dfd}}$ = , $P < 0.001$). Standard error bars are shown. Means with the same capital letter are not significantly different.

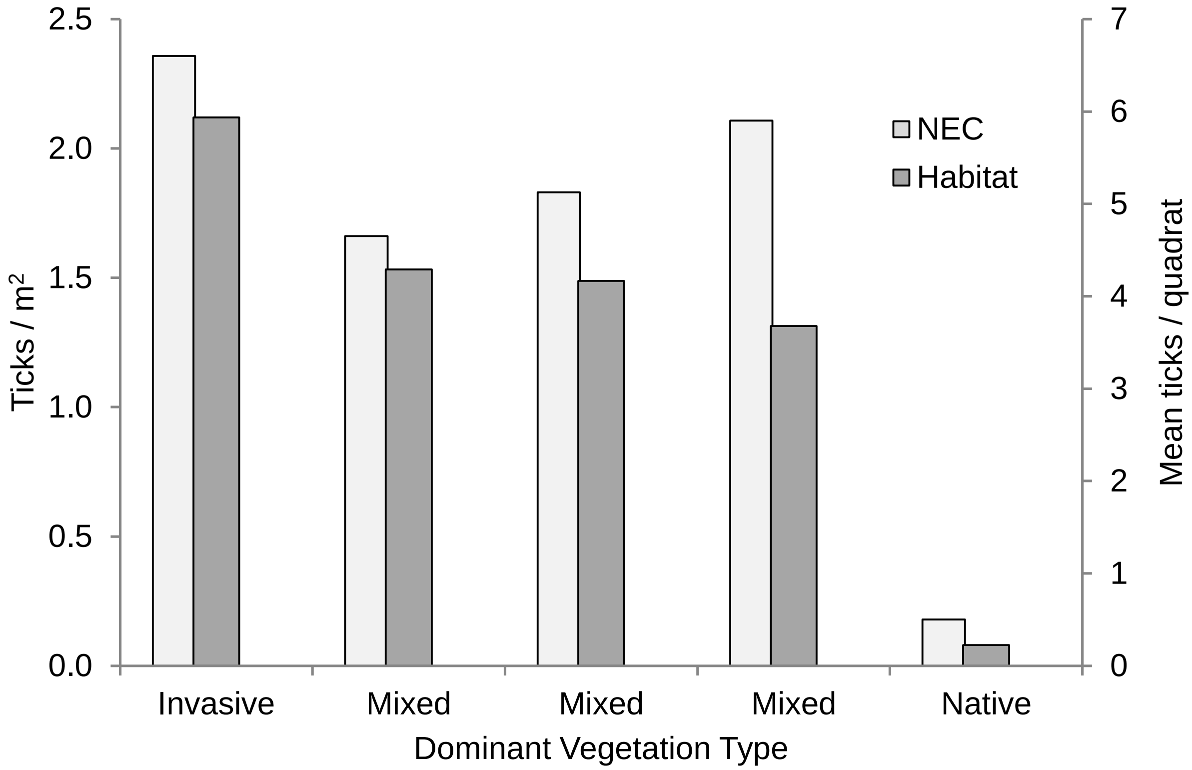

Figure 2.8. Mean abundance of ticks in the habitat and on New England cottontails (NEC) at five sites in New York, 2015-2017 (Spearman's $\rho = 0.95$, $P = 0.014$).

CHAPTER 3: EIMERIA OF THE NEW ENGLAND COTTONTAIL RABBIT (*SYLVILAGUS TRANSITIONALIS)* AND EASTERN COTTONTAIL (*SYLVILAGUS FLORIDANUS)* IN THE LOWER HUDSON VALLEY OF NEW YORK

ABSTRACT

The endoparasites of the imperiled, native New England cottontail (*Sylvilagus transitionalis,* NEC) and sympatric non-native eastern cottontail (*Sylvilagus floridanus*, EC) are relatively unknown in New York. An exploratory study in 2015 identified a high prevalence of several unidentified *Eimeria* species in the cottontail populations. Identifying the species of *Eimeria* is important because the pathology likely differs among species. The objectives of this study were to identify the *Eimeria* species found in NEC and EC populations in New York using morphological characteristics and genetic comparisons and to determine whether the presence of EC at a site affected the species composition and abundance of *Eimeria* in NEC. We found *Eimeria* spp. in 25 of 28 NEC (89.3%) and 6 of 10 EC (60.0%). Of the infected cottontails, 13 NEC (46.4%) and 3 EC (30.0%) hosted more than one species. Seven species were identified: *Eimeria audubonii*, *E. poudrei*, *E. irresidua, E. media, E. neoirresdiua*, *E. maior,* and one undescribed species. *Eimeria irresidua* and *E. media* are known to be pathogenic in cottontails, but the degree of virulence of the others species is unknown. There was a difference in the prevalence of *Eimeria* with species pooled between the NEC and EC populations, but not when any one species of *Eimeria* was considered. There was no difference in the number of infections or coinfections in NEC between sites where EC were rare and where they were common. *Eimeria*-related pathogenesis and the potential for exposure to internal parasites should be considerations in ongoing management for the conservation of NEC, including habitat restoration, transplant of NEC among existing sites, and reintroduction from captive populations.

Keywords: coinfection, eastern cottontail, *Eimeria*, New England cottontail, parasites, *Sylvilagus floridanus*, *Sylvilagus transitionalis*

INTRODUCTION

Parasites of imperiled species are of interest, as they can affect individual health and population persistence (Hudson et al. 1998). They have been found to limit host populations, cause cyclic population crashes, and cause mortality (Clausen et al. 1980, Davis et al. 1980). The introduction of a new host species may expose native species to novel parasites, thereby further threatening already vulnerable populations (Tizzani et al. 2014). The NEC (NEC; *Sylvilagus transitionalis*) is an imperiled endemic mammal of the northeastern United States. Historically, the range of NEC spanned from southern Maine to Connecticut and from the Hudson River in New York to Cape Cod, Massachusetts, but has since contracted into five small distinct populations on the periphery of this range (Fig. 1; Chapman 1992, Litvaitis and Jakubas 2004, Fenderson et al. 2011). Within these populations, NEC are organized in metapopulations in a fragmented landscape with potentially low dispersal among them (Fenderson et al. 2011). A competitor species, the eastern cottontail (EC; *Sylvilagus floridanus*) has been expanding eastward since being introduced by state agencies and private organizations during the early 1900s and is now sympatric with NEC throughout most of the NEC range (Probert and Litvaitis 1996). The presence of EC throughout much of NEC habitat has raised concerned about direct competition and indirect effects such as increased parasitism.

Some conservation measures have been utilized to reestablish the NEC population without consideration of parasites. Translocations from wild populations and reintroductions from captive populations are being used to supplement NEC populations throughout their range.

Introductions such as these increase stress on individuals. Parasitism is known to be higher on stressed individuals because there is a decrease in the host's immune response (Ould and Welch 1980). If parasite abundance is high in the area into which cottontails are released, the rabbits may have difficulty surviving and reproducing (Ould and Welch 1980, Scott 1988, Su et al. 2005). There is also the potential of moving parasite species into new areas. This introduction of parasites may increase the abundance or diversity and negatively affect the host population targeted for conservation (Weigl 1968, Nelson and Smith 1976, Johnson et al. 2008).

Endoparasites of EC have been well studied since the early 1900s (Bertolino et al. 2010, Duszynski and Couch 2013, Tizzani et al. 2014), but very little is known about the endoparasites of the NEC. An exploratory study conducted in 2015 in New York found several different genera of endoparasites in pellets, including multiple types of *Eimeria*, but was unable to identify to species (Unpublished). *Eimeria* is a genus of apicomplexan parasite. Apicomplexans contain an apical complex of microtubules and live within body cavities of most animals. Identification to species is important because some *Eimeria* species, such as *Eimeria flavescens*, are serious pathogens to rabbits. Other species (e.g., *Eimeria irresidua*) are only mildly pathogenic, and for some species little is known about effects on cottontails (Duszynski and Couch 2013). Although coccidiosis, a disease caused by *Eimeria*, is unknown in the *Sylvilagus* spp., it has been reported in endangered pygmy rabbits (*Brachylagus idahoensis*) and may be responsible for recent declines in some of their isolated populations (Duszynski et al. 2005).

This study entails a structural survey of the *Eimeria* found in the native NEC and nonnative EC populations in the Lower Hudson Valley of New York using morphological characteristics and genetic comparisons. The objectives of this study were to compare *Eimeria* species composition between the cottontail species, and to determine whether the presence of EC at a site affected the number of NEC infected with one or more species of *Eimeria*. This information would be used to determine if *Eimeria* bears further examination as a limiting factor in the NEC populations and if the presence of EC has affected the *Eimeria* species in NEC. Our results will also inform the use of conservation strategies that have the potential to spread parasites among NEC populations, including translocation and reintroduction of captive animals.

MATERIALS AND METHODS

Study Area

Cottontail pellets were collected in NEC habitat in the Lower Hudson Valley (LHV) of New York east of the Hudson River (41.453339 N, 73.704338 W). The New York State Department of Environmental Conservation (NYSDEC) had conducted fecal pellet surveys throughout state parks in the LHV and sites were selected with known historical NEC populations. Habitat for NEC ranged included sites dominated by native vegetation, invasive exotic vegetation, and a mix of both. Eighteen sites that contained NEC were selected in Putnam, Dutchess, Westchester and Columbia Counties, to include areas where prior pellet surveys had indicated prevalent EC, sparse EC, and no EC.

Sample Collection

Three sites were trapped per week with Tomahawk and Havahart traps that were baited with apple slices. The traps were set in areas with NEC signs or in NEC habitat if there were no obvious cottontail signs. Traps were checked daily with five nights open and two nights closed. The traps remained at a site for two weeks unless trapping success was unacceptably low; if so, trapping would continue at the site for another week. Species were tentatively identified in the field using morphological characteristics (Litvaitis et al. 1991). Cottontails were eartagged and a tissue sample was collected for genetic species confirmation (Scharine et al. 2011). Sites where 17% of known alive cottontails were EC were designated as “EC common” and sites with less than 17% EC were designated as “EC rare”. This 17% threshold was a natural breakpoint in our dataset, at which there were adequate numbers of NECs in each category for further analysis (Cheeseman 2017). All animal capture and handling procedures were approved by the State University of New York College of Environmental Science and Forestry Institutional Animal Care and Use Committee (SUNY-ESF IACUC Protocol 120801).

When a cottontail was trapped, fecal samples were collected from under the trap. At least 5 pellets from an individual were placed in two empty 25-mL screw-cap vials. One vial contained potassium chromate solution, which induces sporulation of *Eimeria*. The other vial was frozen for genetic analysis. Five volumes of 2.5% (w/v) potassium chromate were added to one volume of feces leaving a layer of air to allow the oocysts atmospheric oxygen (Duszynski and Marquardt 1969).

Fecal Floats

Forty-six fecal floats were conducted on samples from 38 cottontails (28 NEC and 10 EC). Centrifugal fecal floats were performed using a Sheather’s sugar solution (1.33 specific gravity). Microscopic examination of the slides was used to identify parasite species on each slide. A camera was used to record sporulated oocysts for morphological identification. Pictures were taken at 400x and 1000x for morphological measurements. Once the slides were photographed they were rinsed with sterile saline solution into a sterile 1.5 mL tube to collect the oocysts which were then pelleted at 1800 rpm for 5 minutes. The supernatant was pipetted off and the tubes were stored at -20°C for subsequent genetic analysis. If there were no *Eimeria* seen, fecal floats were done again with the sample to ensure no oocysts were missed.

Eimeria *Measurements*

Measurements were conducted using Motic Images Plus 2.0 ® (Motic North America, Richmond, British Columbia V6V 2K9) software following Duszynski and Wilber (1997) guidelines for classification of *Eimeria* species. Measurements included oocyst length and width, ratio of the oocyst length to width, sporocyst length and width, ratio of the sporocyst length to width, and characteristics of the wall and inner layers. Characteristics that were recorded were: the presence of a micropyle (m) and its width (mw), the presence of a micropyle cap (mc) and its width (mcw) and depth (mcd) the presence of a residuum (or) and its diameter and description, and the presence of polar granules (pg). I noted the presence of the following structures in or on the sporocyst: surface features such as sporopodia (spop), adhering membranes (mem), ridges, residuum (sr) and its diameter and description; stieda body (sb), the substieda body (ssb), and the parastieda body (psb). In the sporozoite the presence or absence of the refractile body (srb) and its diameter and shape, and the nucleus (n) was noted. Only sporulated oocysts were used for measurements. The measurements from oocysts of the same species were averaged; the average and the range of the measurements along with features of the oocyst were compared to known Eimeriid species that affect members of the genera *Sylvilagus, Lepus,* and *Oryctolagus* (Duszynski and Marquardt 1969, Wiggins and Rothenbacher 1979, Duszynski and Couch 2013).

Genetic Analysis

Eleven rabbit pellet samples were selected for cloning based on mixed sequences coming out as *Eimeria*/other apicomplexan in Basic Local Alignment Search Tool ® (BLAST) (National Center for Biotechnology Information, U.S. National Library of Medicine 8600 Rockville Pike, Bethesda MD, 20894 USA) as well as the number of species seen under the microscope. The sequencing for *Eimeria* spp. in the pellets was routinely accomplished by means of a PCR targeting 18E (CTGGTTGATCCTGCCAGT) and Coc2R (CTTTCGCAGTAGTTCGTC) as described by Whipps et al. (2012). Amplifications were performed in 50-µl reactions containing 25.0 µl of Quick-Load® Taq 2X Master Mix (New England BioLabs, Inc., Ipswich, Massachusetts 01938, USA), 1.0 µl of forward and reverse primer, 3.0 µl of DNA and 21.0 µl of PCR H_2O. Amplifications were performed on a C1000™ Thermal Cycle (BioRad Laboratories, Hercules, California 94547, USA) with initial denaturation at 95°C for 3 min, followed by 34 cycles of 95°C for 30 sec, 53°C for 30 sec, 68°C for 60 sec, and a final extension of 68°C for 5 min. Product amplification was observed on a 1.5% agarose gel containing GelRed™ Nucleic Acid Gel Stain (Biotium, Hayward, California 94545, USA). PCR products were purified using the E.Z.N.A. Cycle Pure Kit (Omega Bio-Tek, Norcross, Georgia 30071, USA) and DNA quantified using a DNA spectrophotometer (NanoDrop Technologies Wilmington, Delaware 19810, USA).

The purified DNA was then cloned into the sequencing vector, pCR4-TOPO, using a TOPO TA cloning kit. The recombinant plasmids were first screened by using M13R (-27) (CAGGAAACAGCTATGAC) and T7 (GTAATACGACTCACTATAG) primers to determine successful amplicon insertion. Amplifications were performed in 25.0-µl reactions containing 12.5 µl Quick-Load® Taq 2X Master Mix, 0.5 µl of each primer, and a portion of each colony template. Amplifications were performed on a C1000™ Thermal Cycle with initial denaturation at 95°C for 3 min, followed by 34 cycles of 95°C for 30 sec, 56°C for 30 sec, 68°C for 60 sec, and a final extension of 68°C for 5 min. Resulting fragments were restriction digested to look for different fragmentation patterns in each clone. The restriction digest was performed in 25.0-µl reactions using 2.5 µl 10X Cutsmart Buffer, 0.5 µl AluI, 0.5 µl NlaIII, 10.0 PCR screening product, and 11.5 PCR H_2O. The reaction conditions for digest were 37°C for 2 hr and 80°C for 20 min. Several representatives of clones with unique digestion patterns were transferred to 3 mL of broth containing 50 ug/ml kanamycin for outgrowth. The culture tubes were maintained at 37°C and centrifuged at 180 rpm for at least 16 hours. Plasmids were purified using E.Z.N.A.® Plasmid Mini Kit I plasmid (Omega Bio-Tek, Norcross, Georgia 30071, USA) purification kits, and sent for sequencing with T27 and M13R (-27) plasmid primers. Sequencing reactions were carried out with the ABI BigDye Terminator Cycle Sequencing Ready Reaction Kit v3.1, using the ABI3730xl Genetic Analyzer (Applied Biosystems, Foster City, California). The genetic results were compared to the morphological identification.

Analysis

Number of cottontails infected with *Eimeria* and number of coinfections were modeled as a function of host species and our indicator of EC prevalence (“common” and “rare”) and their interaction using mixed-effects Poisson-lognormal regression in a Bayesian framework (Kery 2010), where site was the random effect. A normally-distributed dispersion parameter was included in the log-linear predictor because model fitting suggested extra-Poisson variation. Three chains ran for 15000 iterations with a burn-in length of 3000. Uninformative flat normal priors were used for regression coefficients and an uninformative uniform prior for variance components. The proportion of individuals carrying each *Eimeria* species was compared between the two rabbit species using logistic regression in a Bayesian framework (Kery 2010). Three chains ran for 10000 iterations with a burn-in length of 1000. Uninformative flat normal priors were used for regression coefficients. The prevalence of *Eimeria* (proportion of cottontail individuals with at least one species of parasite) was compared between the cottontail species using a Chi-square test (Venables and Ripley 2002) in R (R Core Team 2013).

RESULTS

Eimeria species were found in 25 of 28 NEC (89.3%) and 6 of 10 EC (60.0%). Of the infected cottontails, 13 NEC (46.5%) and 3 EC (30.0%) had coinfections. The prevalence of *Eimeria* was higher in NEC than EC ($\chi^2_1 = 4.205$, $P = .040$). Seven species were identified (Table 3.1): *Eimeria audubonii* (Duszynski and Marquardt 1969), *Eimeria. poudrei* (Duszynski and Couch 2013), *Eimeria irresidua* (Kessel and Jankiewicz 1931), *Eimeria media* (Kessel and Jankiewicz 1931), *Eimeria neoirresdiua* (Duszynski and Couch 2013), *Eimeria maior* (Carvalho 1942), and one undescribed species. Prevalence of *E. poudrei* was higher in NEC than in EC. Prevalance of the other six *Eimeria* species were not statistically different between the two cottontail species (Table 3.1).

There was no difference in the prevalence of infections or coinfections of *Eimeria* in NEC between sites where EC were common and where they were rare (Figure 3.2). Where EC were rare, 19 of 21 NEC (90.5%) were infected with *Eimeria*; nine of which (42.9%) had single species infections and ten NEC (47.6%) were infected with more than one species. Where EC were common, six NEC (85.7%) were infected with *Eimeria*. Four NEC (57.1%) were infected with a single species and two NEC (28.6%) were infected with multiple species.

Genetic data

Twelve pellet samples were evaluated by DNA sequencing. From these samples, 12 unique sequence types were obtained (Table 3.2), with multiple sequences found in 10 of the samples. Based on BLAST searches, one sequence matched an uncultured eukaryote, with the remainder best matching apicomplexans, but not all could be attributed to the *Eimeria* species we observed microscopically. Three of the sequences were best matches with members of the Cryptosporidiidae. Two sequences best matched GenBank entries from species in the subclass Gregarinasina.. The remaining six sequences belonged to the family Eimeriidae.

The DNA sequence ID 2 (Table 3.2) was consistently found in cottontails that were infected with what was morphologically identified as *E. irresidua* (Table 3.3). The sequence ID 3 likely represents *E. neoirresdiua* based on the overlap in occurrence. The three cottontails infected with genetic ID 8 were all infected with *E. poudrei*. Because ID 8 is most likely *E. poudrei*, genetic ID 6 is most likely *E. maior.* Sequence ID 4 occurred in the same rabbits as *E. audubonni* was identified. The sequence type ID 5 was only found in cottontail 725, and because we can already account for ID 2 as *E. irresidua*, and ID 3 represents *E. neoirresdiua* in 725, ID 5 likely represents the unknown species.

Undescribed species

The undescribed species we identified most closely resembles *Eimeria neoleoporis* (Carvalho 1942) but differs from it in having an oocyst residuum (Fig. 3.5). The oocyst is elongate-ellipsoidal to slightly cylindroidal. It tapers slightly toward the M. There are two walls.

The outer wall is smooth and the same thickness throughout. Oocyst L X W: 41.4 x 21.6 (37.4-45.1 X 15.5-26.2); L/W ratio: 1.9; M: present; OR: present; PG: absent. There is a distinctive M and centrally located OR. Some distinctive features are the oocyst and elongated ellipsoidal shape.

The sporocyst L X W: 36.5 X 16.6 (37.4-41.0 X 15.4-22.6); L/W ratio: 2.3; SB: present: SSB: present; PSB absent; SR: present; SR characteristics: well-defined, varying in shape; SZ: 14-17 x 7-9; SRB characteristics: well-defined, large, occupying half of sporocyst. Some definitive characteristics of the sporocyst: presence of SB, varying sized SR, large SRB.

DISCUSSION

The higher prevalence of *Eimeria* in NEC than EC is in accord with recent findings that within host species, introduced populations are less heavily parasitized than native populations (Torchin et al. 2003). The availability of a native host lessens the parasitic burden on the introduced one, and may enable the introduced host to thrive. The possibility of introducing parasites with a new host would depend on the number of introduced hosts (Weigl 1968, Price et al. 1986). Because EC were introduced to the northeast in large numbers, EC could have brought *Eimeria* species into NEC habitat and thus introduced the new species to the native host. NEC may not have evolved with the *Eimeria* species. If not, they may be more susceptible to parasitism by new species (Price et al. 1986, Taraschewski 2006, Kelly et al. 2009). Parasites that are introduced successfully can impact native species severely if the native host is maladapted to novel parasites (Taraschewski 2006). Reproducing our results with a larger sample size of each species would be informative.

The prevalence of *Eimeria* species found in EC is consistent with previous studies on that host. *E. irresidua* had a higher prevalence than the 4-10% previously seen in EC (Kessel and Jankiewicz 1931). *Eimeria poudrei* was recently documented in an introduced population of EC in Italy (Bertolino et al. 2010). All of the species identified have been found in *Sylvilagus* spp. in North America (Carvalho 1942, Duszynski and Marquardt 1969, Duszynski and Couch 2013). However, none have been documented within New York and *E. poudrei* and *E. irresidua* have only been found in California and Colorado. With the expansion of the EC range into the northeast, it is possible that they have carried *Eimeria* into New York from the Midwest and introduced them into the NEC population. The lack of data regarding *Eimeria* species found historically in New York makes it difficult to determine the geographic origin of these parasites. EC have still not reached Maine, so an examination of the parasites of NEC there would be informative.

Levels of infection in a population can be prolonged depending on the mode of transmission. A common path of transmission of *Eimeria* spp. is from host parents to their young, which would facilitate the transmission of parasites within small populations (Kelly et al. 2009, Krichbaum et al. 2010, Telfer et al. 2010). The high proportion of NEC that are infected with *Eimeria* may sustain *Eimeria* infestations within NEC populations by such a pathway.

The diversity of *Eimeria* in cottontails that I documented was similar to other studies (Morgan and Waller 1940, Carvalho 1942, Duszynski and Marquardt 1969, Bertolino et al. 2010). *Eimeria irresidua* is one of the more pathogenic intestinal coccidians reported in rabbits (Kessel and Jankiewicz 1931). Capillaries and the epithelium can become extravasated of blood and may slough and become denuded. *E. irresidua* can destroy many epithelial cells and cause inflammation and hyperemia in cottontails. *Eimeria media* is moderate to very pathogenic;

juvenile cottontails with high levels of infection have been found with fatal coccidiosis due to destruction of the intestinal epithelium (Pellerdy and Babos 1953). Susceptible juveniles present with swollen and inflamed mucosa of the large and small intestine. Other studies found that high levels of infection caused weight loss, reduced food intake, and diarrhea, but no deaths (Duszynski and Couch 2013). *E. piriformis* pathology is not very well known. However, Cheissin (1948) found that one-month old rabbits that were given experimental exposures became sluggish, had a loss of appetite, rough hair coats, and diarrhea by eight days. *E. maior* is considered non-pathogenic (Carvalho 1942). The pathology of *E. audubonii* and *E. neoirresdiua* is unknown (Duszynski and Couch 2013). Therefore, the presence of these species in New York in a cottontail of conservation concern warrants further investigation into their potential for pathology.

When parasites coinfect a host, they may interact, and may have synergistic negative effects on the host species (Telfer et al. 2010, Ezenwa and Jolles 2011, Gorsich et al. 2014). Co-infecting parasites can change the infection risk, intensity, and the fitness consequences of the infection (Graham et al. 2005, Telfer et al. 2010, Pedersen and Antonovics 2013). Parasites can suppress the host immune response and may increase the likelihood of infection or the intensity of an infection by a different parasite (Su et al. 2005). Coinfections with *Eimeria* species increase the intestinal damage and loss of body weight, increase the number of bacteria in the gut suggesting decrease in gut integrity, and can change the host inflammatory response when compared to single infections (Park et al. 2008). Co-infections occurred in almost half of the NEC that we sampled, increasing the likelihood that NEC are exposed to the negative effects of *Eimeria.* These coinfections can reduce the immune response of the cottontails making them more susceptible to other infections and parasitism.

Eimeria are extremely diverse due to their host specificity (Duszynski and Couch 2013). Many species found in lagomorphs are not genetically sequenced and cannot be found in public genetic database making it difficult to use genetic sequencing to identify species. This study aimed to use the same parasites observed on wetmount preparations for morphological identification as the source material for DNA sequencing. However, the regular occurrence of confection by multiple *Eimeria* species made it difficult to identify which genetic sequences belonged to morphologically identified *Eimeria.* Ideally, a larger sample size would increase the number of single species infection for testing, and also provide more opportunities for connecting DNA sequences to morphologically identified species even when coinfections occur.

Little is known about the abundance and diversity of *Eimeria* within the community structure of lagomorphs. This information is needed to determine the effects of these *Eimeria* on the imperiled NEC population. Because pathology is highly linked to number of coccidians and coinfections, additional investigations should focus on determining the number of *Eimeria* present in NEC individuals. Studies on the relationships between *Eimeria* species may lead to understanding parasite host relationships and interactions. Further studies on the pathology of *Eimeria* on cottontails where pathology is unknown would be beneficial to determine the overall population effects *Eimeria* might be having on NEC.

Given that none of the *Eimeria* species identified have been previously documented in wildlife populations in New York, there is a potential that the introduction of EC carried these parasites into NEC range. Two of the species are known to be pathogenic in EC thus are likely be pathogenic in NEC populations at high levels of infection. The pathology of the other *Eimeria* species found must be investigated in order to determine effects on NEC population. When translocating and reintroducing cottontails, it is important to understand the parasite composition of sites to increase the likelihood the new cottontails will survive and reproduce. Introducing stressed individuals into sites with high abundances of pathogenic *Eimeria* or a high diversity of parasites will increase the stress on cottontails and potentially decrease their immune response making it much harder for them to establish.

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LITERATURE CITED

Bertolino, S., L. Hofmannová, M. Girardello, and D. Modry. 2010. Richness, origin and structure of an Eimeria community in a population of Eastern cottontail (*Sylvilagus floridanus*) introduced into Italy. Parasitology 137:1179–1186.

Carvalho, J. C. de M. 1942. The coccidia of wild rabbits of Iowa, with special reference to *Eimeria neoleporis* Carvalho, 1942.

Chapman, J. A. 1992. Systematics and biogeography of the New England cottontail, *Sylvilagus transitionalis* (Bangs, 1895), with the description of a new species from the Appalachian Mountains. Proceedings of the Biological Society of Washington. 105:841–866.

Cheissin, E. M. 1948. Development of two rabbit intestinal coccidia *Eimeria piriformis* and *E. intestinalis.* Uch. Zap. Karelo-Finsk III:179–187.

Clausen, B., A. Dam, K. Elvestad, H. Krogh, and H. Thing. 1980. Summer mortality among caribou calves in West Greenland. Nordisk veterinaermedicin 32:291–300.

Davis, J. L., P. Valkenburg, and H. V. Reynolds. 1980. Population dynamics of Alaska’s western arctic caribou herd. Proceedings of 2nd International Reindeer/Caribou Symposium, Alaska Department of Fish and Game, Fairbanks, Alaska.

Duszynski, D. W., and L. Couch. 2013. The biology and identification of the coccidia (apicomplexa) of rabbits of the world. Newnes.

Duszynski, D. W., L. Harrenstien, L. Couch, and M. M. Garner. 2005. A pathogenic new species of Eimeria from the pygmy rabbit, *Brachylagus idahoensis*, in Washington and Oregon, with description of the sporulated oocyst and intestinal endogenous stages. Journal of Parasitology 91:618–623.

Duszynski, D. W., and W. C. Marquardt. 1969. Eimeria (Protozoa: Eimeriidae) of the cottontail rabbit *Sylvilagus audubonii* in Northeastern Colorado, with descriptions of three new species. Journal of Protozoology 16:128–137.

Duszynski, D. W., and P. G. Wilber. 1997. A guideline for the preparation of species descriptions in the Eimeriidae. Journal of Parasitology 83:333–336.

Ezenwa, V. O., and A. E. Jolles. 2011. From host immunity to pathogen invasion: the effects of helminth coinfection on the dynamics of microparasites. Integrative and Comparative Biology 51:540–551.

Fenderson, L. E., A. I. Kovach, J. A. Litvaitis, and M. K. Litvaitis. 2011. Population genetic structure and history of fragmented remnant populations of the New England cottontail (*Sylvilagus transitionalis*). Conservation Genetics 12:943–958.

Gorsich, E. E., V. O. Ezenwa, and A. E. Jolles. 2014. Nematode–coccidia parasite co-infections in African buffalo: Epidemiology and associations with host condition and pregnancy. International Journal for Parasitology: Parasites and Wildlife 3:124–134.

Graham, A. L., T. J. Lamb, A. F. Read, and J. E. Allen. 2005. Malaria-Filaria coinfection in mice makes malarial disease more severe unless filarial infection achieves patency. Journal of Infectious Diseases 191:410–421.

Hudson, P. J., A. P. Dobson, and D. Newborn. 1998. Prevention of population cycles by parasite removal. Science 282:2256–2258.

Johnson, P. T. J., R. B. Hartson, D. J. Larson, and D. R. Sutherland. 2008. Diversity and disease: community structure drives parasite transmission and host fitness. Ecology Letters 11:1017–1026.

Kelly, D. W., R. A. Paterson, C. R. Townsend, R. Poulin, and D. M. Tompkins. 2009. Parasite spillback: A neglected concept in invasion ecology? Ecology 90:2047–2056.

Kery, M. 2010. Introduction to WinBUGS for ecologists: Bayesian approach to regression, ANOVA, mixed models and related analyses. 1 edition. Academic Press, Amsterdam ; Boston.

Kessel, J. F., and A. Jankiewicz. 1931. Species differentiation of the coccidia of the domestic rabbit based on a study of the oöcysts. American Journal of Epidemiology 14:304–324.

Krichbaum, K., C. G. Mahan, M. A. Steele, G. Turner, and P. J. Hudson. 2010. The potential role of *Strongyloides robustus* on parasite-mediated competition between two species of flying squirrels (glaucomys). Journal of Wildlife Diseases 46:229–235.

Litvaitis, J. A., and W. Jakubas. 2004. New England cottontail (*Sylvilagus transitionalis*) assessment 2004. Maine Department of Inland Fisheries and Wildlife, Bangor, USA.

Litvaitis, J. A., D. L. Verbyla, and M. K. Litvaitis. 1991. A field method to differentiate New England and eastern cottontails. Transactions of the Northeast Section of the Wildlife Society 48:11–14.

Morgan, B. B., and E. F. Waller. 1940. A survey of the parasites of the Iowa cottontail (*Sylvilagus floridanus mearnsi*). Journal of Wildlife Management 4:21–26.

Nelson, B. C., and C. R. Smith. 1976. Ecological effects of a plague epizootic on the activities of rodents inhabiting caves at lava beds national monument, California. Journal of Medical Entomology 13:51–61.

Ould, P., and H. E. Welch. 1980. The effect of stress on the parasitism of mallard ducklings by *Echinuria uncinata* (Nematoda: Spirurida). Canadian Journal of Zoology 58:228–234.

Park, S. S., H. S. Lillehoj, P. C. Allen, D. W. Park, S. FitzCoy, D. A. Bautista, and E. P. Lilleho. 2008. Immunopathology and cytokine responses in broiler chickens coinfected with *Eimeria maxim*a and *Costridium perfringens* with the use of an animal model of necrotic enteritis. Avian Diseases 52:14–22.

Pedersen, A. B., and J. Antonovics. 2013. Anthelmintic treatment alters the parasite community in a wild mouse host. Biology Letters 9:20130205.

Pellerdy, L., and Babos. 1953. Untersuchungen Ober die endogene Entwicklung sowie pathologische Bedeutung von Eimeria media. Acta Veterinaria Academiae Scientiarum Hungaricae 3:173–178.

Price, P. W., M. Westoby, B. Rice, P. R. Atsatt, R. S. Fritz, J. N. Thompson, and K. Mobley. 1986. Parasite mediation in ecological interactions. Annual Review of Ecology and Systematics 17:487–505.

Probert, B. L., and J. A. Litvaitis. 1996. Behavioral interactions between invading and endemic lagomorphs: Implications for conserving a declining species. Biological Conservation 76:289–295.

R Core Team. 2013. R: a language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.

Scharine, P. D., C. K. Nielsen, E. M. Schauber, L. Rubert, and J. C. Crawford. 2011. Occupancy, detection, and habitat associations of sympatric lagomorphs in early-successional bottomland forests. Journal of Mammalogy 92:880–890.

Scott, M. E. 1988. The impact of infection and disease on animal populations: implications for conservation biology. Conservation Biology 2:40–56.

Su, Z., M. Segura, K. Morgan, J. C. Loredo-Osti, and M. M. Stevenson. 2005. Impairment of protective immunity to blood-stage malaria by concurrent nematode infection. Infection and Immunity 73:3531–3539.

Taraschewski, H. 2006. Hosts and parasites as aliens. Journal of Helminthology 80:99–128.

Telfer, S., X. Lambin, R. Birtles, P. Beldomenico, S. Burthe, S. Paterson, and M. Begon. 2010. Species interactions in a parasite community drive infection risk in a wildlife population. Science (New York, N.Y.) 330:243–246.

Tizzani, P., S. Catalano, L. Rossi, P. J. Duignan, and P. G. Meneguz. 2014. Invasive species and their parasites: eastern cottontail rabbit *Sylvilagus floridanus* and *Trichostrongylus affinis* (Graybill, 1924) from Northwestern Italy. Parasitology Research 113:1301–1303.

Torchin, M. E., K. D. Lafferty, A. P. Dobson, V. J. McKenzie, and A. M. Kuris. 2003. Introduced species and their missing parasites. Nature 421:628.

Venables, W. N., and B. D. Ripley. 2002. Modern applied statistics with S. Fourth. Springer, New York.

Weigl, P. D. 1968. The distribution of the flying squirrels, *Glaucomys volans* and *G. sabrinus*; An evaluation of the competitive exclusion idea. PhD Dissertation, Duke University, Durham, North Carolina.

Whipps, C. M., J. W. Fournie, D. A. Morrison, C. Azevedo, E. Matos, P. Thebo, and M. L. Kent. 2012. Phylogeny of fish-infecting Calyptospora species (Apicomplexa: Eimeriorina). Parasitology Research 111:1331–1342.

Wiggins, J. P., and H. Rothenbacher. 1979. *Eimeria azul* sp. n. (protozoa: Eimeriidae) from the eastern cottontail, *Sylvilagus floridanus*, in Pennsylvania. Journal of Parasitology 65:393–394.

Table 3.1. *Eimeria* species found in cottontails, number of infected individuals, prevalance of *Eimeria* in New England cottontails (NEC, N = 28) and eastern cottontails (EC, N =10), and 95% credible interval on the difference in prevalance between the species in New York 2015-2017.

	Number of infected cottontails		Percent		95% Credible Interval on Species Difference
Eimeria species	NEC	EC	NEC	EC	
Eimeria audubonii	1	1	3.6%	10.0%	-0.80 – 4.60
Eimeria poudrei	6	1	21.4%	10.0%	8.50 – 69.5 *
Eimeria irresidua	5	2	17.6%	20.0%	-0.70 - 16.30
Eimeria neoirresdiua	11	3	39.3%	30.0%	-1.80 - 2.80
Eimeria media	2	0	7.2%	0.0%	-0.70 - 4.50
Eimeria maior	2	3	7.2%	30.0%	-0.10 – 4.60
Undescribed	1	1	3.6%	10.0%	-9.90 – 9.70

Table 3.2. Matching BLAST hits from DNA sequencing of pellets from cottontails in New York 2015-2017.

ID	1	2	3	4	5	6	7	8	9	10	11	12
TM		X						X				
706		X	X			X						
708		X	X	X								
714		X	X					X			X	
715			X									
716								X				X
720		X										
725		X			X							
731		X	X									
737			X				X			X		
755	X											
756	X		X				X		X			

01: *Eimeria exigua/irresidua;* 02: *Eimeria exigua/polita*; 03: *Eimeria vejdovskyi/perforans*; 04: Eimeriidae; 05: Eimeriidae/*Monocystis agilis A*; 06: Eimeriidae/*Monocystis agilis B*; 07: Cryptosporidiidae; 08: Cryptosporidiidae/Eimeriidae; 09: *Paraschneideria*; 10: *Stenophora*; 11: Cryptosporidium/Colpodellidae; 12: Uncultured eukaryote/*Leidyana erratica*

Table 3.3. *Eimeria* species found in New England (NEC) and eastern cottontails (EC) in New York 2015-2017.

Cottontail ID	Cottontail Species	*E. poudrei*	*E. irresidua*	*E. neoirresdiua*	*E. audubonni*	*E. media*	*E. maior*	Unk.
706	EC	X	X				X	
708			X	X	X		X	X
726				X				
756				X			X	
TM	NEC	X	X					
627		X						
654		X						
699		X		X				
711						X		
714		X		X				
715			X	X			X	
716		X						
720				X				
723				X				
725			X	X				X
729				X				
731				X				
737			X		X	X		
738							X	
740				X				
755				X				
757			X	X				

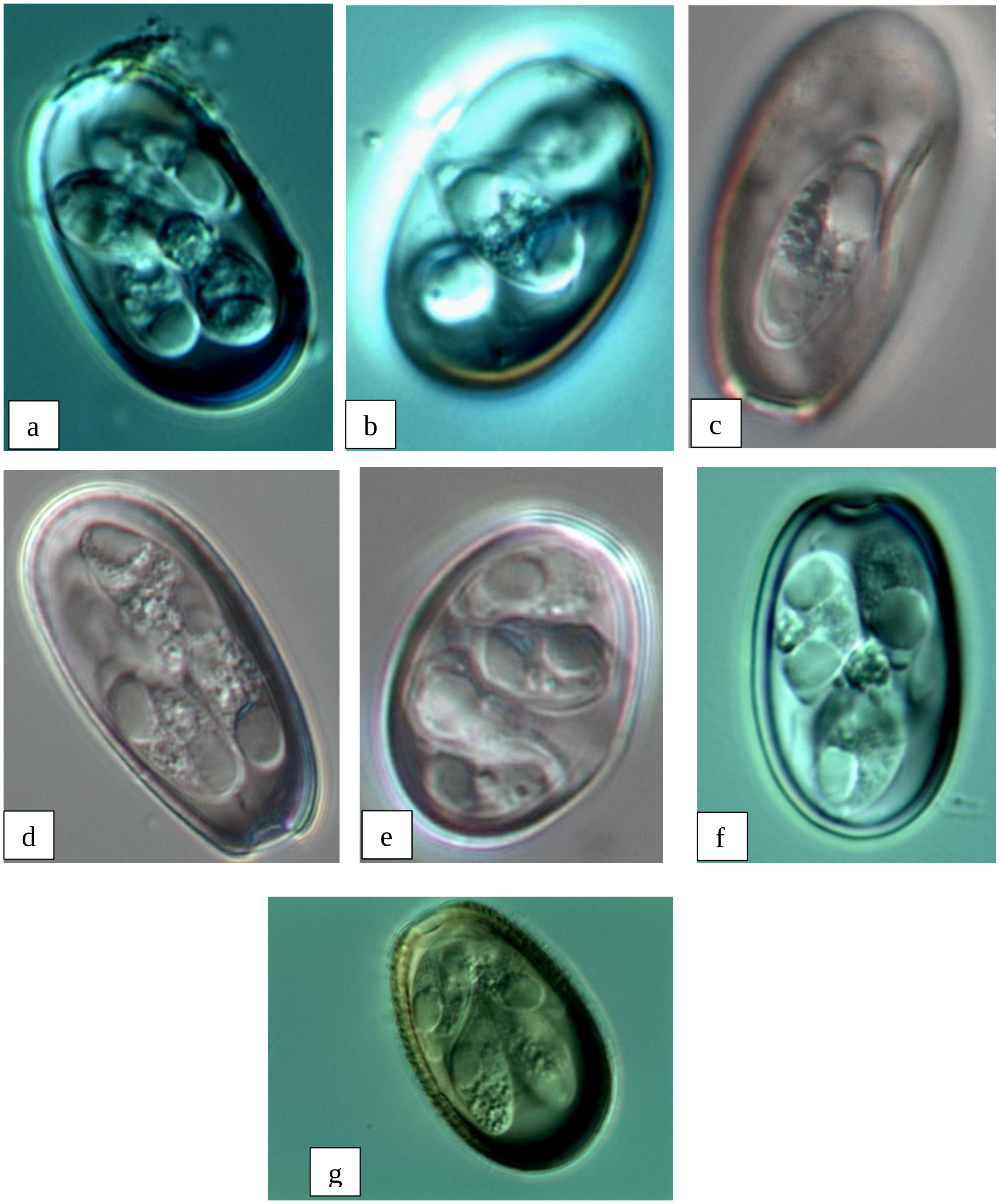


Figure 3.1. Sporulated oocysts recovered from feces of *Sylvilagus* spp. in New York in 2015-2016: *Eimeria media* (a,b), *Eimeria irresidua* (c,d), *Eimeria audubonii* (e), *Eimeria neoirresdiua* (f), and *Eimeria maior* (g).

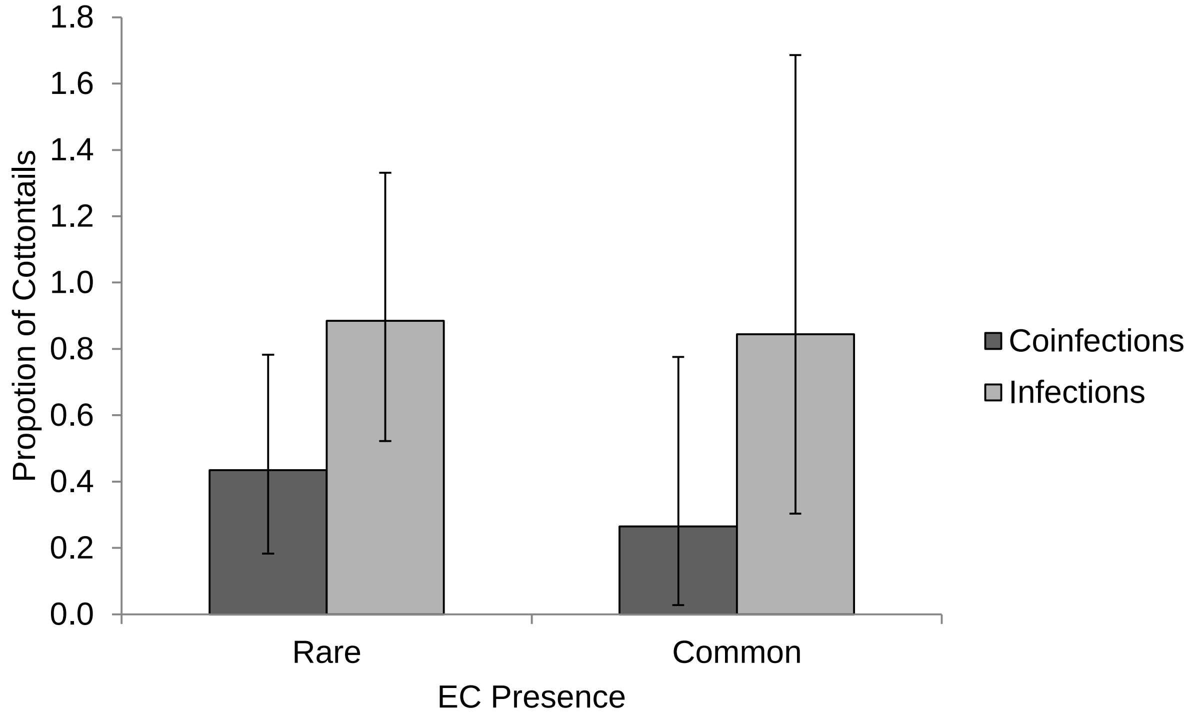


Figure 3.2: Proportion of New England cottontails with infections and coinfections where eastern cottontails were rare (comprised <17% of known alive cottontails at a site, $N = 21$) or common ($N = 7$) in New York 2015-2017 with 95% credible intervals.

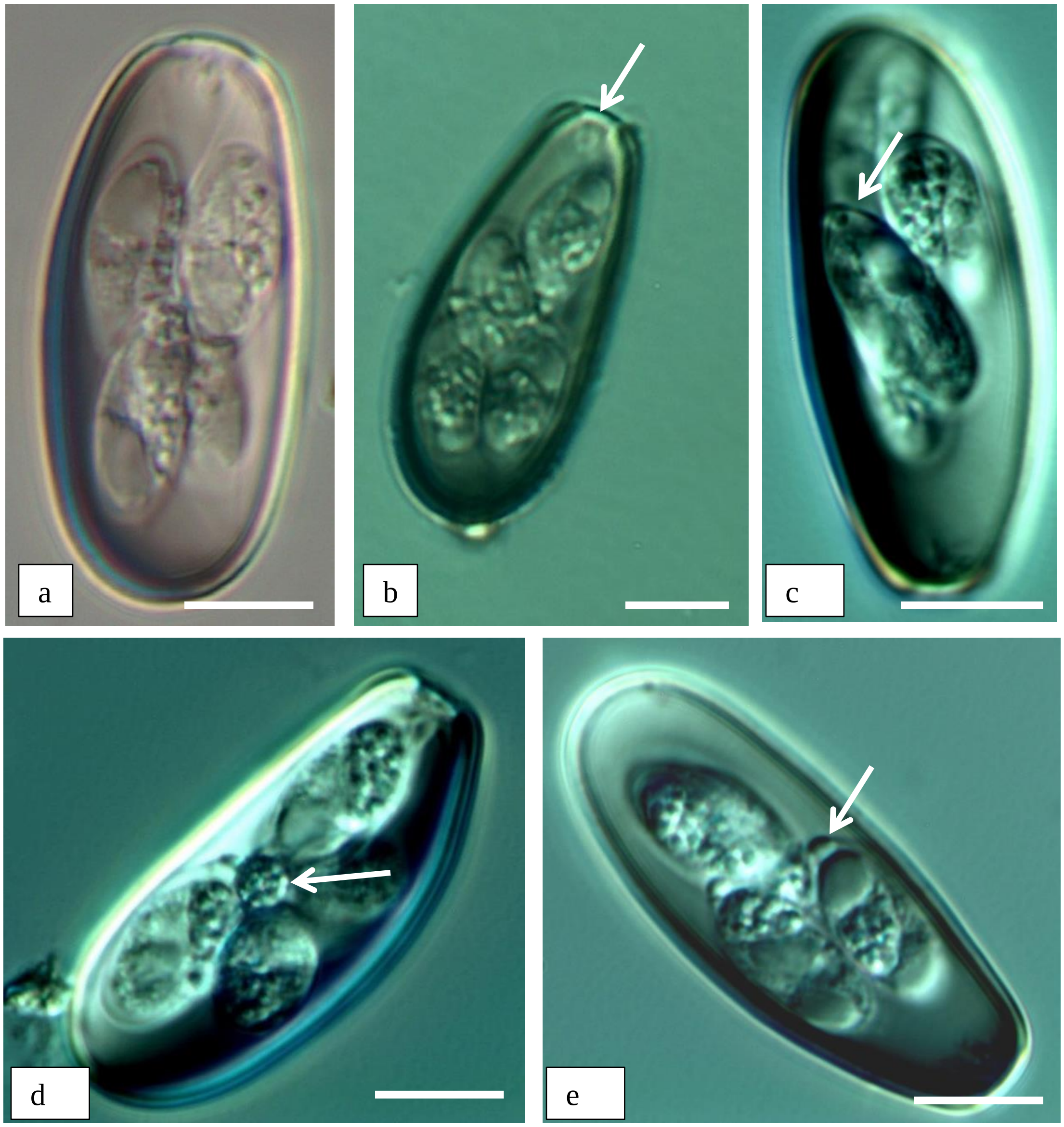


Figure 3.3. Sporulated undescribed species of *Eimeria* recovered from feces of *Sylvilagus* spp in New York in 2015-2016. Note the presence of large micropyle (b), substieda body (c), centrally located oocyst residuum (d), and steida body (e) with 10 µm scale.

CHAPTER 4: DISCUSSION

OVERVIEW

Little research has been done on the parasites of the New England cottontail (*Sylvilagus transitionalis*, NEC). However, we do know that other mammalian species with small, insular populations are more likely to be negatively affected by changes in parasite abundance and diversity than large populations (Smith and Cheatum 1944). There are a multitude of negative effects parasites have on their host species. Parasites can cause an increase in mortalities, impact the fitness of their host, cause population crashes, and can cause indirect competition between host species (Clausen et al. 1980, Davis et al. 1980, Price et al. 1986, Hudson et al. 1998). The introduction of a non-native host such as the eastern cottontail (*Sylvilagus floridanus*) can increase these negative effects and potentially increase the abundance or diversity of parasites on NEC (Price et al. 1986, Hanley et al. 1995, Hoberg et al. 2002, Tizzani et al. 2014). Besides the addition of the non-native host species, there is a high presence of invasive vegetation in much of NEC habitat. Sites where invasives such as Japanese barberry (*Berberis thunbergii*) is the dominant vegetation type have been found to have higher tick densities than those sites dominated by native shrubs (Elias et al. 2006). My goal was to understand how the presence of EC affects the tick abundance and diversity on the NEC, how invasive vegetation was affecting ticks found in NEC habitat, how the abundance of ticks in the habitat affected the abundance of ticks on the NEC, and to determine what *Eimeria* species were found in NEC and EC.

SIGNIFICANT FINDINGS

Abundance and diversity of ticks

Tick densities were higher in the NEC population than EC population at our sites. This could expose the NEC to negative effects of tick burdens such as anemia, emaciation, and infection (Jellison and Kohls 1938). Many of the adult cottontails were found with infections on their necks and swollen tick bite sites. There were several observed juvenile mortalities with tick burdens over 70 ticks per cottontail. Based on necropsy done at the Wildlife Health Unit (New York State Department of Environmental Conservation), they were diagnosed as having died from tick infestation with signs of abscessed tick bites and associated subcutaneous hemorrhage. High tick burdens on both adult and juvenile cottontails means ticks could be aiding in the decline of the NEC. Ticks are likely increasing the mortalities of juvenile cottontails and potentially affecting adult cottontails when ticks are searching for blood meals. The highest tick burdens were in Spring, which is the breeding season and when cottontails are recovering from being nutritionally stressed during Winter (Ould and Welch 1980, Scott 1988, Brown et al. 2003). The negative effects of parasitism are more prevalent in populations and individuals when they are stressed. There are numerous studies linking tick abundances to a decline in mammalian populations (Smith and Cheatum 1944, Cooney et al. 2005) and tick abundances on NEC in these sites are exceeding the numbers that are known to cause negative effects in cottontails.

There was a difference between the tick burdens of NEC and EC, which was surprising because the two cottontail species are morphologically similar (Chapman 1975, Saunders 1988) and, because ticks some ticks are generalists, they likely do not select for one cottontail species over the other. Thus, the difference in tick abundance found between cottontail species is most likely linked to habitat selection rather than the physical characteristics of the cottontails. NEC select for dense shrubs and invasive vegetation such as Japanese barberry more often than EC (Cheeseman 2017). Selecting for this habitat exposes NEC to higher amounts of ticks because invasive vegetation such as these species are known to increase tick abundances in the environment (Williams et al. 2009).

The only difference in prevalence of a tick species was for the rabbit tick (*Haemaphysalis leporispalustris)*. Rabbit ticks prefer early successional and grass habitat (Camin and Drenner 1978). More rabbit ticks were found on EC than NEC supporting the conclusion that EC are more likely to select for grassland or spend more time in habitat where rabbit ticks are found. The most prevalent tick species was the black-legged tick (*Ixodes scapularis*), a known vector of *Borrelia burgdorferi*, the causative agent of Lyme disease. The proportion of cottontails infected with this tick increases the likelihood that the NEC population is exposed to this disease. A small sample of NEC was selected for exploratory testing for the presence of tick-borne pathogen *B. burgdorferi*. No cottontails came back positive, but it was a very small sample size and further testing should be done to see if NEC are acting as a reservoir host.

The higher tick burdens of NEC in areas of dense shrub and invasive vegetation supports the correlation we found on our sites between the dominant vegetation type and tick abundance. The invasive dominated sites had higher tick abundances than native or mixed vegetation sites. The species of invasive vegetation found on the sites are Japanese barberry, Japanese honeysuckle (*Lonicera japonica*), multiflora rose (*Rosa multiflora*) and oriental bittersweet (*Celastrus orbiculatus*). Vegetation of this type is known to form dense canopy cover that may be used by cottontails as protection from predators and weather. This vegetation may provide important cover for the imperiled native NEC, but utilizing this vegetation may be increasing their tick burdens. The canopy cover increases the relative humidity of the microhabitat allowing ticks to quest for longer periods of time thus increasing their ability to mature and reproduce (Needham and Teel 1991, Adler et al. 1992, Williams et al. 2009). Also Cheeseman (2017) found that when EC are common in a habitat patch, NEC are more likely to select for invasive shrubs such as Japanese barberry than when EC are rare. This increased use of invasive vegetation in the presence of EC could increase their exposure to ticks.

Unlike previous studies conducted, we found tick abundances to be higher in grass habitat than shrub habitat (Randolph and Storey 1999, Lindström and Jaenson 2003, Williams et al. 2009). However, tick drags are better at collecting adult questing ticks than nymphs or larvae because they drag over the top of the shrubs rather than in the leaf litter underneath (Mays et al. 2016). This methodological artifact may explain the differences between our tick abundances in shrub and grass and those found in other studies utilizing a wider variety of collection methods (Gherman et al. 2012, Rulison et al. 2013). The tick abundances in shrublands may seem lower because the tick drags did not collect nymphs and larvae from the leaf litter underneath the shrubs (Rulison et al. 2013). My methodological approach may also explain the difference in seasonal abundances of ticks. In Fall, nymphs have matured into questing adults and are more likely to be collected because they are questing on shrubs thus producing a higher tick abundance.

Understanding the parasitic species composition of habitat in a site is important when introducing new cottontails to an area. Captive breeding programs and translocations are being used to supplement NEC populations. It is important to determine the tick populations in reintroduction locations. Cottontails placed in areas where tick abundances are high or where there is a high prevalence of tick-borne pathogens may be immunologically maladapted to combat infections increasing the chance of mortalities. Stressed individuals are more susceptible to parasitism and will have a more difficult time surviving and reproducing when there is a high abundance of ticks (Ould and Welch 1980, Scott 1988). The timing of these translocations may also be important. If cottontails are being introduced to sites in Fall when tick abundances are high and forage availability is started to diminish, it is likely they will have higher tick burdens and be negatively affected.

For management purposes, it may be important to manage for habitat that does not foster tick growth. Ticks are linked to juvenile mortalities and burdens are high enough to negatively affect adult cottontails. When trying to manage cottontail habitat to benefit NEC, it is important to consider the potential role ticks are playing in limiting this population. Managing for invasive vegetation to decrease the tick population at sites may decrease the abundances of ticks and decrease the exposure NEC have to ticks and tick-borne diseases. It is also important when translocating cottontails to a site to determine if the tick abundances of the new site are high. Introducing NEC to sites where tick abundances are high may increase mortalities of these already stressed cottontails and make it more difficult for the small population to survive. Cottontails that have not been exposed to ticks, such as cottontails from captive breeding programs, may be more susceptible to ticks. Animals that have been exposed to tick bites can grow resistance to ticks and be more capable of surviving higher tick burdens. Ensuring that captive bred cottontails are exposed to parasites prior to release may increase the likelihood of survival in areas of high parasitism.

Eimeria *of New England Cottontails*

There was a higher prevalence of *Eimeria* within the NEC population than EC population. The prevalence of the *Eimeria* species found in NEC were similar to the prevalence in EC in different studies. The species that were found have predominately been found in the Midwest, Colorado, and California. Since EC have expanded their range eastwards, there is the potential that they brought these parasites with them (Hanley et al. 1995, Hoberg et al. 2002, Torchin et al. 2003, Tizzani et al. 2014). If EC evolved with these specific parasites, they may be less susceptible to parasitism by these *Eimeria* (Price et al. 1986). NEC may be maladapted to these species, which is why there is a higher prevalence in their population (Taraschewski 2006). However, there is little research done on the *Eimeria* species found in New York making it difficult to know if these *Eimeria* species are native or introduced. There is a possibility that these *Eimeria* species are common throughout the state and this is the first time they have been documented. If this is the case, then it is likely that there is some other factor affecting the species of *Eimeria* in the cottontail population. Studies have found that *Eimeria* species are limited by environmental factors such as humidity and temperature (Turner and Getz 2010). Because EC select for grass habitat, potentially the lack of canopy cover decreases the humidity thus decreasing the opportunity for oocysts to sporulate and become infective. There was no effect of the presence of EC on the number of NEC infected with *Eimeria* or the amount of cottontails infected with multiple species of *Eimeria*.

There were seven species of *Eimeria* found in the cottontail population. Two of the species are known to cause coccidiosis in cottontails. These two species, *E. media* and *E. irresidua* were more prevalent in NEC potentially exposing NEC to the negative effects of *Eimeria* more than EC. Approximately half of the infected NEC were coinfected. Coinfections increase the chance that cottontails will exhibit signs of coccidiosis. When there are multiple infections, there is generally a higher abundance of *Eimeria*. A higher abundance of a pathogenic species is more likely to exhibit signs of coccidiosis. Because *Eimeria* are more likely to affect juvenile cottontails (Duszynski and Couch 2013) there may be overall population level effects. If juveniles are exposed to high rates of infection, a large proportion of NEC may be affected by coccidiosis.

IMPORTANT QUESTIONS AND FUTURE DIRECTIONS

Since little research has been done on parasites of NEC, there are many questions that need to be answered. I will elaborate on a few that are the most pressing.

Impacts of Ticks on New England Cottontails

The study needs to be expanded to other states where NEC are found. It is important to understand if high tick burdens on cottontails are only located in the Lower Hudson Valley or if it is a common occurrence throughout their range. If high tick burdens are affecting the New York population, it is likely they are affecting NEC populations in other states. Studies have been done investigating the effects of ticks on cottontails (Smith and Cheatum 1944, Mörner 1992, Cooney et al. 2005), but it would be useful to determine if NEC are showing negative health effects associated with high tick burdens. Comparing the body condition to the abundance and species of ticks found on the cottontails may show if ticks are affecting the fitness of NEC populations in New York.

Eimeria *in New England Cottontails*

The presence of *Eimeria* in the NEC is not surprising because *Eimeria* is a common apicomplexan. However, these species have not been documented in New York and it is unknown if they are common. Research looking into the *Eimeria* species in the environment and in other hosts would help expand the knowledge of apicomplexans in New York. Surveying the

Eimeria species of NEC populations in Maine where EC have not colonized will help to determine if EC introduced these species to the NEC populations in New York or if these *Eimeria* species are native to the area. Clinical studies investigating the pathology of the species where it is unknown would be useful to determine if researchers should be concerned with the parasite population in the NEC. It is also important to determine the level of infection NEC are exposed to. Most of the *Eimeria* are only pathogenic with high numbers (Carvalho 1942, Duszynski et al. 2005, Duszynski and Couch 2013) thus quantifying oocyst abundance is crucial when determining how these species are going to affect the hosts. If possible, it would also be useful to necropsy NEC to determine if there are any signs of coccidiosis within the liver or intestine.

CONCLUSIONS

This research on the parasites of the NEC in New York has yielded some new information. I was able to show that NEC are more parasitized by ticks than EC and are thus more exposed to the effects of tick infestation than their non-native competitor. I also show that there are mortalities linked to ticks within our NEC population and ticks should be considered as a potential factor limiting the NEC population. I describe species of *Eimeria* that had not been documented in New York and one species that has not been identified previously. Two of the species I found are known to cause coccidiosis in the closely related EC and may be negatively affecting the NEC population. This work provides a foundation for a better understanding of the parasites found in NEC, and for clarifying the conservation implications of parasites of the NEC.

LITERATURE CITED

Adler, G. H., S. R. Telford, M. L. Wilson, and A. Spielman. 1992. Vegetation structure influences the burden of immature *Ixodes dammini* on its main host, *Peromyscus leucopus*. Parasitology 105 (Pt 1):105–110.

Arneberg, P., A. Skorping, B. Grenfell, and A. F. Read. 1998. Host densities as determinants of abundance in parasite communities. Proceedings: Biological Sciences 265:1283–1289.

Brown, M. J. F., R. Schmid-Hempel, and P. Schmid-Hempel. 2003. Strong context-dependent virulence in a host–parasite system: reconciling genetic evidence with theory. Journal of Animal Ecology 72:994–1002.

Camin, J. H., and R. W. Drenner. 1978. Climbing behavior and host-finding of larval rabbit ticks (*Haemaphysalis leporispalustris*). Journal of Parasitology 64:905–909.

Carvalho, J. C. de M. 1942. The coccidia of wild rabbits of Iowa, with special reference to *Eimeria neoleporis* Carvalho, 1942.

Chapman, J. A. 1975. *Sylvilagus transitionalis*. Mammalian Species 1–4.

Cheeseman, A. E. 2017. Factors limiting recovery of the New England cottontail in New York. Dissertation, State University of New York College of Environmental Science and Forestry, Syracuse, NY.

Clausen, B., A. Dam, K. Elvestad, H. Krogh, and H. Thing. 1980. Summer mortality among caribou calves in West Greenland. Nordisk veterinaermedicin 32:291–300.

Cooney, J. C., W. Burgdorfer, M. K. Painter, and C. L. Russell. 2005. Tick infestations of the eastern cottontail rabbit (*Sylvilagus floridanus*) and small rodentia in northwest Alabama and implications for disease transmission. Journal of Vector Ecology: Journal of the Society for Vector Ecology 30:171–180.

Davis, J. L., P. Valkenburg, and H. V. Reynolds. 1980. Population dynamics of Alaska’s western arctic caribou herd. Proceedings of 2nd International Reindeer/Caribou Symposium, Alaska Department of Fish and Game, Fairbanks, Alaska.

Duszynski, D. W., and L. Couch. 2013. The biology and identification of the coccidia (Apicomplexa) of rabbits of the world. Newnes.

Duszynski, D. W., L. Harrenstien, L. Couch, and M. M. Garner. 2005. A pathogenic new species of Eimeria from the pygmy rabbit, *Brachylagus idahoensis*, in Washington and Oregon, with description of the sporulated oocyst and intestinal endogenous stages. Journal of Parasitology 91:618–623.

Elias, S. P., C. B. Lubelczyk, P. W. Rand, E. H. Lacombe, M. S. Holman, and R. P. Smith. 2006. Deer browse resistant exotic-invasive understory: an indicator of elevated human risk of exposure to *Ixodes scapularis* (Acari: Ixodidae) in southern coastal Maine woodlands. Journal of Medical Entomology 43:1142–1152.

Gherman, C. M., A. D. Mihalca, M. O. Dumitrache, A. Györke, I. Oroian, M. Sandor, and V. Cozma. 2012. CO2 flagging - an improved method for the collection of questing ticks. Parasites & Vectors 5:125.

Hanley, K. A., D. M. Vollmer, and T. J. Case. 1995. The distribution and prevalence of helminths, coccidia and blood parasites in two competing species of gecko: implications for apparent competition. Oecologia 102:220–229.

Hoberg, E. P., S. J. Kutz, J. Nagy, E. Jenkins, B. Elkin, M. Branigan, and D. Cooley. 2002. *Protostrongylus stilesi* (Nematoda: Protostrongylidae): ecological isolation and putative host-switching between Dall's sheep and muskoxen in a contact zone. Comparative Parasitology 69:1–9.

Hudson, P. J., A. P. Dobson, and D. Newborn. 1998. Prevention of population cycles by parasite removal. Science 282:2256–2258.

Jellison, W. L., and G. M. Kohls. 1938. Tick-host anemia: a secondary anemia induced by *Dermacentor andersoni* Stiles. Journal of Parasitology 24:143–154.

Lindström, A., and T. G. T. Jaenson. 2003. Distribution of the common tick, *Ixodes ricinus* (Acari: Ixodidae), in different vegetation types in Southern Sweden. Journal of Medical Entomology 40:375–378.

Mays, S. E., A. E. Houston, and R. T. Trout Fryxell. 2016. Comparison of novel and conventional methods of trapping ixodid ticks in the southeastern U.S.A. Medical and Veterinary Entomology 30:123–134.

Mörner, T. 1992. The ecology of tularaemia. Rev. sci. tech. Off. int. Epiz. 11:1123–1130.

Needham, G. R., and P. D. Teel. 1991. Off-host physiological ecology of ixodid ticks. Annual review of entomology 36:659–681.

Ould, P., and H. E. Welch. 1980. The effect of stress on the parasitism of mallard ducklings by *Echinuria uncinata* (Nematoda: Spirurida). Canadian Journal of Zoology 58:228–234.

Price, P. W., M. Westoby, B. Rice, P. R. Atsatt, R. S. Fritz, J. N. Thompson, and K. Mobley. 1986. Parasite mediation in ecological interactions. Annual Review of Ecology and Systematics 17:487–505.

Randolph, S. E., and K. Storey. 1999. Impact of microclimate on immature tick-rodent host interactions (Acari: Ixodidae): implications for parasite transmission. Journal of Medical Entomology 36:741–748.

Rulison, E. L., I. Kuczaj, G. Pang, G. J. Hickling, J. I. Tsao, and H. S. Ginsberg. 2013. Flagging versus dragging as sampling methods for nymphal *Ixodes scapularis* (Acari: Ixodidae). Journal of Vector Ecology 38:163–167.

Saunders, D. A. 1988. Eastern cottontail. Page 216 *in*. Adirondack mammals. Adirondack Wildlife Program, State University of New York, College of Environmental Science and Forestry.

Scott, M. E. 1988. The impact of infection and disease on animal populations: implications for conservation biology. Conservation Biology 2:40–56.

Smith, R. H., and E. L. Cheatum. 1944. Role of ticks in decline of an insular cottontail population. Journal of Wildlife Management 8:311–317.

Taraschewski, H. 2006. Hosts and parasites as aliens. Journal of Helminthology 80:99–128.

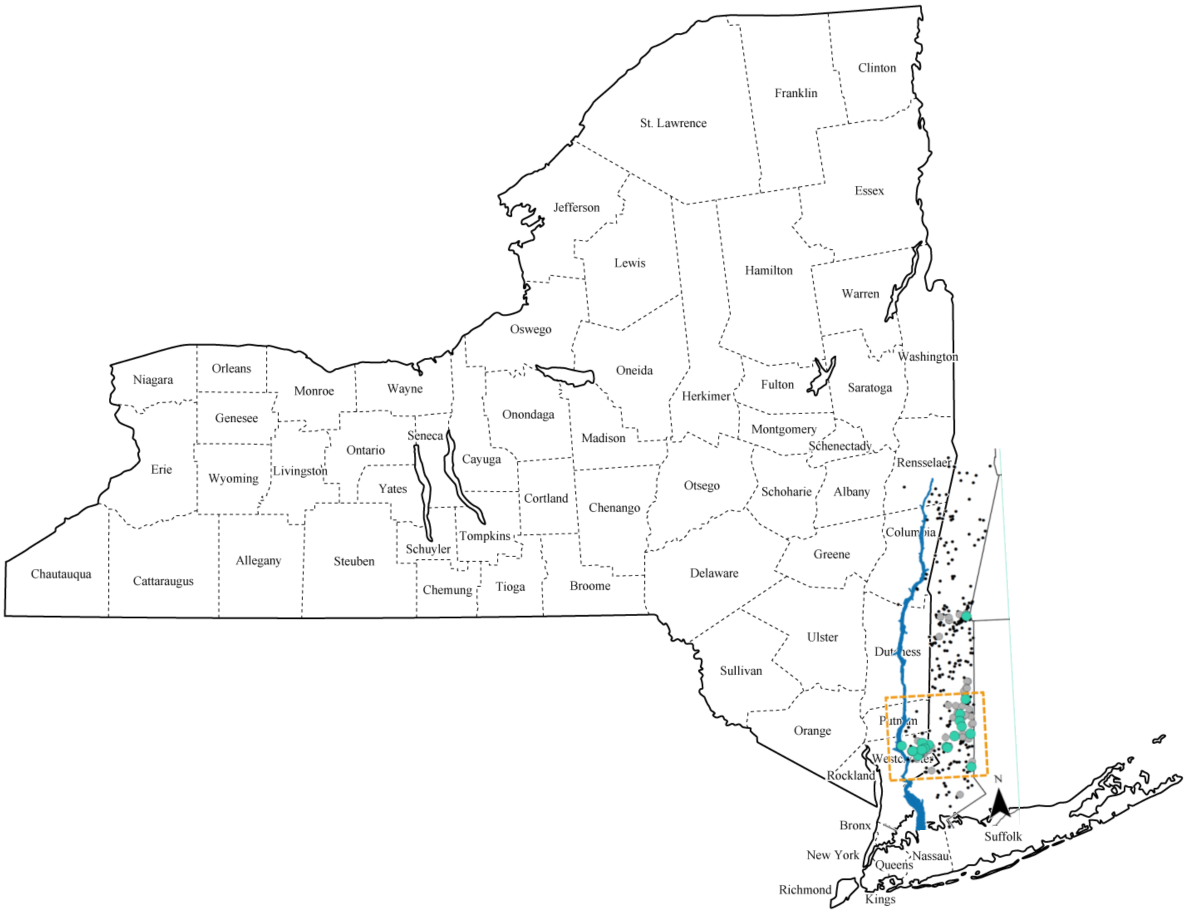
Tizzani, P., S. Catalano, L. Rossi, P. J. Duignan, and P. G. Meneguz. 2014. Invasive species and their parasites: eastern cottontail rabbit *Sylvilagus floridanus* and *Trichostrongylus affinis* (Graybill, 1924) from Northwestern Italy. Parasitology Research 113:1301–1303.

Torchin, M. E., K. D. Lafferty, A. P. Dobson, V. J. McKenzie, and A. M. Kuris. 2003. Introduced species and their missing parasites. Nature 421:628.

Turner, W. C., and W. M. Getz. 2010. Seasonal and demographic factors influencing gastrointestinal parasitism in ungulates of Etosha National Park. Journal of Wildlife Diseases 46:1108–1119.

Williams, S. C., J. S. Ward, T. E. Worthley, and K. C. Stafford. 2009. Managing Japanese barberry (Ranunculales: Berberidaceae) infestations reduces blacklegged tick (Acari: Ixodidae) abundance and infection prevalence with *Borrelia burgdorfer*i (Spirochaetales: Spirochaetaceae). Environmental Entomology 38:977–984.

APPENDIX 1: Locations where New England and eastern cottontails were trapped in the Hudson River Valley in Dutchess and Putnam counties of New York 2015-2017.



APPENDIX 2: Tick drag data from New England cottontail sites in New York. 2015-2016.

Date	Temp	Site	ID	Distance	Ticks	Vegetation	Type	Period
3/17/2016	17.1	6	N/A	30.1	0	leaf litter	0	1
3/17/2016	17.1	6	sm601	71.2	9	barberry	1	1
3/17/2016	17.1	6	sm602	99.2	24	barberry	1	1
3/17/2016	17.1	6	sm603	59.9	13	grass	3	1
3/17/2016	17.1	6	sm604	41.2	9	barberry	1	1
3/17/2016	17.1	6	sm605	74.8	15	grass	3	1
3/17/2016	17.1	6	N/A	27.2	0	barberry	1	1
3/17/2016	17.1	6	N/A	84.2	6	barberry	1	1
3/17/2016	17.1	6	sm606	22.3	0	Grass	3	1
3/17/2016	17.1	6	sm607	102.3	4	barberry	1	1
3/17/2016	17.1	6	sm608	99.7	15	barberry	1	1
3/17/2016	17.1	6	sm609	100.2	3	barberry	1	1
3/17/2016	17.1	6	sm610	59.3	8	barberry	1	1
3/17/2016	17.1	6	sm611	40.3	2	grass	3	1
3/17/2016	17.1	6	sm612	102.3	19	barberry	1	1
3/31/2016	19.2	6	sm601	29.1	1	leaf litter	0	2
3/31/2016	19.2	6	N/A	69.2	0	barberry	1	2
3/31/2016	19.2	6	N/A	99.2	0	barberry	1	2
3/31/2016	19.2	6	sm602	57.9	2	grass	3	2
3/31/2016	19.2	6	sm603	43.2	6	barberry	1	2
3/31/2016	19.2	6	N/A	76.8	0	grass	3	2
3/31/2016	19.2	6	N/A	27.2	0	barberry	1	2
3/31/2016	19.2	6	sm604	83.2	4	barberry	1	2
3/31/2016	19.2	6	N/A	20.3	0	Grass	3	2
3/31/2016	19.2	6	N/A	100.3	0	barberry, rose	1	2
3/31/2016	19.2	6	sm605	97.7	5	barberry	1	2
3/31/2016	19.2	6	N/A	102.2	0	barberry	1	2
3/31/2016	19.2	6	sm606	59.3	3	barberry	1	2
3/31/2016	19.2	6	N/A	39.3	0	grass	3	2
3/31/2016	19.2	6	sm607	103.3	4	barberry	1	2
4/14/2016	13.4	6	N/A	30.1	0	leaf litter	0	3
4/14/2016	13.4	6	N/A	70.2	0	barberry	1	3
4/14/2016	13.4	6	sm601	99.2	2	barberry	1	3
4/14/2016	13.4	6	N/A	56.9	0	grass	3	3
4/14/2016	13.4	6	N/A	44.2	0	barberry	1	3
4/14/2016	13.4	6	N/A	76.8	0	grass	3	3
4/14/2016	13.4	6	N/A	26.2	0	barberry	1	3
4/14/2016	13.4	6	sm602	83.2	1	barberry	1	3
4/14/2016	13.4	6	N/A	21.3	0	grass	3	3
4/14/2016	13.4	6	N/A	99.3	0	autumn olive	1	3

4/14/2016	13.4	6	N/A	96.7	0	barberry	1	3
4/14/2016	13.4	6	sm603	103.2	3	barberry	1	3
4/14/2016	13.4	6	N/A	59.3	0	barberry	1	3
4/14/2016	13.4	6	N/A	40.3	0	grass	3	3
4/14/2016	13.4	6	N/A	104.3	0	barberry	1	3
4/28/2016	14.1	6	N/A	29.9	0	leaf litter	0	4
4/28/2016	14.1	6	N/A	70	0	barberry	1	4
4/28/2016	14.1	6	sm601	100.1	3	barberry	1	4
4/28/2016	14.1	6	N/A	57.1	0	grass	3	4
4/28/2016	14.1	6	N/A	44.9	0	barberry	1	4
4/28/2016	14.1	6	N/A	75.8	0	grass	3	4
4/28/2016	14.1	6	N/A	26.1	0	barberry	1	4
4/28/2016	14.1	6	sm602	84.1	6	barberry	1	4
4/28/2016	14.1	6	N/A	22.2	0	grass	3	4
4/28/2016	14.1	6	N/A	99.8	0	autumn olive	1	4
4/28/2016	14.1	6	sm603	98.9	3	barberry	1	4
4/28/2016	14.1	6	sm604	100.2	5	barberry	1	4
4/28/2016	14.1	6	N/A	60.1	0	barberry	1	4
4/28/2016	14.1	6	N/A	40.5	0	grass	3	4
4/28/2016	14.1	6	N/A	101.1	0	barberry	1	4
5/14/2016	21.2	6	N/A	29.9	0	leaf litter	0	5
5/14/2016	21.2	6	sm601	70	1	barberry	1	5
5/14/2016	21.2	6	N/A	100.1	0	barberry	1	5
5/14/2016	21.2	6	N/A	57.1	0	grass	3	5
5/14/2016	21.2	6	N/A	44.9	0	barberry	1	5
5/14/2016	21.2	6	N/A	75.8	0	grass	3	5
5/14/2016	21.2	6	sm602	26.1	1	barberry	1	5
5/14/2016	21.2	6	N/A	84.1	0	barberry	1	5
5/14/2016	21.2	6	N/A	22.2	0	grass	3	5
5/14/2016	21.2	6	sm603	99.8	1	autumn olive	1	5
5/14/2016	21.2	6	N/A	98.9	0	barberry	1	5
5/14/2016	21.2	6	N/A	100.2	0	barberry	1	5
5/14/2016	21.2	6	N/A	60.1	0	barberry	1	5
5/14/2016	21.2	6	N/A	40.5	0	grass	3	5
5/14/2016	21.2	6	sm604	101.1	2	barberry	1	5
9/26/2016	20.1	6	N/A	29.7	0	leaf litter	0	1
9/26/2016	20.1	6	N/A	67.9	0	barberry	1	1
9/26/2016	20.1	6	N/A	97.2	0	barberry	1	1
9/26/2016	20.1	6	N/A	53.4	0	grass	3	1
9/26/2016	20.1	6	N/A	45.9	0	barberry	1	1
9/26/2016	20.1	6	N/A	73.8	0	grass	3	1
9/26/2016	20.1	6	N/A	23.9	0	barberry	1	1
9/26/2016	20.1	6	N/A	83.7	0	barberry	1	1

9/26/2016	20.1	6	N/A	22.2	0	grass	3	1
9/26/2016	20.1	6	N/A	96.2	0	autumn olive	1	1
9/26/2016	20.1	6	N/A	96.7	0	barberry	1	1
9/26/2016	20.1	6	N/A	99.4	0	barberry	1	1
9/26/2016	20.1	6	N/A	56.7	0	barberry	1	1
9/26/2016	20.1	6	N/A	39.8	0	grass	3	1
9/26/2016	20.1	6	N/A	98.9	0	barberry	1	1
10/4/2016	17.6	6	N/A	30.6	0	leaf litter	0	2
10/4/2016	17.6	6	sm601	61.1	2	barberry	1	2
10/4/2016	17.6	6	sm602	100.9	4	barberry	1	2
10/4/2016	17.6	6	sm603	53.4	2	grass	3	2
10/4/2016	17.6	6	sm604	44.6	1	barberry	1	2
10/4/2016	17.6	6	sm605	72.7	5	grass	3	2
10/4/2016	17.6	6	sm606	22.8	2	barberry	1	2
10/4/2016	17.6	6	sm607	81.9	3	barberry	1	2
10/4/2016	17.6	6	sm608	21.5	1	grass	3	2
10/4/2016	17.6	6	N/A	100.2	0	barberry	1	2
10/4/2016	17.6	6	sm609	99.5	3	barberry	1	2
10/4/2016	17.6	6	sm610	96.9	5	barberry	1	2
10/4/2016	17.6	6	sm611	59.6	2	barberry	1	2
10/4/2016	17.6	6	sm612	39.4	4	grass	3	2
10/4/2016	17.6	6	N/A	100.5	0	barberry	1	2
10/11/2016	16	6	sm601	28.1	3	leaf litter	0	3
10/11/2016	16	6	sm602	67.9	2	barberry	1	3
10/11/2016	16	6	sm603	99.5	4	barberry	1	3
10/11/2016	16	6	N/A	56.2	0	grass	3	3
10/11/2016	16	6	N/A	44.2	0	barberry	1	3
10/11/2016	16	6	sm604	73.2	9	grass	3	3
10/11/2016	16	6	sm605	26.9	2	barberry	1	3
10/11/2016	16	6	N/A	81.9	0	barberry	1	3
10/11/2016	16	6	sm606	20.6	5	grass	3	3
10/11/2016	16	6	sm607	99.4	2	barberry	1	3
10/11/2016	16	6	sm608	99.4	4	barberry	1	3
10/11/2016	16	6	sm609	96.8	2	barberry	1	3
10/11/2016	16	6	sm610	57.3	1	barberry	1	3
10/11/2016	16	6	sm611	39.2	3	grass	3	3
10/11/2016	16	6	sm612	99.5	2	barberry	1	3
10/16/2016	19.8	6	N/A	30.8	0	leaf litter	0	4
10/16/2016	19.8	6	sm601	66.6	2	barberry	1	4
10/16/2016	19.8	6	sm602	96.7	4	barberry	1	4
10/16/2016	19.8	6	sm603	54.1	3	grass	3	4
10/16/2016	19.8	6	sm604	42.2	3	barberry	1	4
10/16/2016	19.8	6	sm605	74.1	2	grass	3	4

10/16/2016	19.8	6	N/A	25.5	0	barberry	1	4
10/16/2016	19.8	6	sm606	82.6	4	barberry	1	4
10/16/2016	19.8	6	sm607	18.3	2	grass	3	4
10/16/2016	19.8	6	N/A	95.9	0	barberry	1	4
10/16/2016	19.8	6	sm608	95.2	5	barberry	1	4
10/16/2016	19.8	6	sm609	95.9	1	barberry	1	4
10/16/2016	19.8	6	sm610	59.7	3	barberry	1	4
10/16/2016	19.8	6	sm611	41.4	2	grass	3	4
10/16/2016	19.8	6	sm612	98.7	4	barberry	1	4
10/23/2016	16.5	6	sm601	27.6	2	leaf litter	0	5
10/23/2016	16.5	6	sm602	66.9	4	barberry	1	5
10/23/2016	16.5	6	sm603	99.2	3	barberry	1	5
10/23/2016	16.5	6	sm604	54.6	2	grass	3	5
10/23/2016	16.5	6	sm605	44.4	5	barberry	1	5
10/23/2016	16.5	6	sm606	72.6	2	grass	3	5
10/23/2016	16.5	6	N/A	26.2	0	barberry	1	5
10/23/2016	16.5	6	sm607	83.1	3	barberry	1	5
10/23/2016	16.5	6	sm608	20.7	2	grass	3	5
10/23/2016	16.5	6	N/A	95.9	0	barberry	1	5
10/23/2016	16.5	6	sm609	99.7	4	barberry	1	5
10/23/2016	16.5	6	N/A	99.8	0	barberry	1	5
10/23/2016	16.5	6	N/A	58.6	0	barberry	1	5
10/23/2016	16.5	6	sm610	40.3	2	grass	3	5
10/23/2016	16.5	6	sm611	99.8	1	barberry	1	5
3/25/2016	19.9	12N	smN01	102.3	3	suckle	1	1
3/25/2016	19.9	12N	N/A	84.6	0	barberry	1	1
3/25/2016	19.9	12N	N/A	17.8	0	leaf litter	0	1
3/25/2016	19.9	12N	smN02	88.2	2	barberry	1	1
3/25/2016	19.9	12N	N/A	11.8	0	leaf litter	0	1
3/25/2016	19.9	12N	N/A	71.4	0	grass	3	1
3/25/2016	19.9	12N	smN03	28.6	1	barberry	1	1
3/25/2016	19.9	12N	N/A	73.8	0	grass	3	1
3/25/2016	19.9	12N	smN04	26.2	3	barberry	1	1
3/25/2016	19.9	12N	smN05	101.2	6	barberry/rose	1	1
3/25/2016	19.9	12N	N/A	31.9	0	barberry	1	1
3/25/2016	19.9	12N	N/A	45.6	0	sparse barberry	1	1
3/25/2016	19.9	12N	N/A	22.6	0	leaf litter	0	1
3/25/2016	19.9	12N	smN06	53.3	2	barberry	1	1
3/25/2016	19.9	12N	N/A	48.2	0	leaf litter	0	1
4/15/2016	15.3	12N	smN01	99.3	4	invasive honey	1	2
4/15/2016	15.3	12N	N/A	83.2	0	barberry	1	2
4/15/2016	15.3	12N	N/A	15.6	0	leaf litter	0	2
4/15/2016	15.3	12N	N/A	86.2	0	barberry	1	2

4/15/2016	15.3	12N	N/A	11.9	0	leaf litter	0	2
4/15/2016	15.3	12N	N/A	66.4	0	grass	3	2
4/15/2016	15.3	12N	N/A	28.5	0	barberry	1	2
4/15/2016	15.3	12N	N/A	69.9	0	grass	3	2
4/15/2016	15.3	12N	N/A	22	0	barberry	1	2
4/15/2016	15.3	12N	smN02	101	2	barberry/rose	1	2
4/15/2016	15.3	12N	N/A	29.2	0	barberry	1	2
4/15/2016	15.3	12N	N/A	46.6	0	sparse barberry	1	2
4/15/2016	15.3	12N	N/A	19.7	0	leaf litter	0	2
4/15/2016	15.3	12N	smN03	51.4	1	barberry	1	2
4/15/2016	15.3	12N	N/A	48.5	0	leaf litter	0	2
4/17/2016	20.1	12N	N/A	100.3	0	invasive honey	1	3
4/17/2016	20.1	12N	smN01	84.6	6	barberry	1	3
4/17/2016	20.1	12N	N/A	16.8	0	leaf litter	0	3
4/17/2016	20.1	12N	smN02	87.2	3	barberry	1	3
4/17/2016	20.1	12N	N/A	11.8	0	leaf litter	0	3
4/17/2016	20.1	12N	smN03	66.4	6	grass	3	3
4/17/2016	20.1	12N	N/A	27.6	0	barberry	1	3
4/17/2016	20.1	12N	N/A	70.8	0	grass	3	3
4/17/2016	20.1	12N	N/A	22.2	0	barberry	1	3
4/17/2016	20.1	12N	smN04	101.2	7	barberry/rose	1	3
4/17/2016	20.1	12N	N/A	28.9	0	barberry	1	3
4/17/2016	20.1	12N	N/A	45.6	0	sparse barberry	1	3
4/17/2016	20.1	12N	smN05	20.6	1	leaf litter	0	3
4/17/2016	20.1	12N	smN06	51.3	3	barberry	1	3
4/17/2016	20.1	12N	N/A	49.2	0	leaf litter	0	3
4/21/2016	20.1	12N	N/A	100.5	0	autumn olive	1	4
4/21/2016	20.1	12N	smN01	82.3	2	barberry	1	4
4/21/2016	20.1	12N	N/A	16.8	0	leaf litter	0	4
4/21/2016	20.1	12N	smN02	85.3	6	barberry	1	4
4/21/2016	20.1	12N	N/A	11.6	0	leaf litter	0	4
4/21/2016	20.1	12N	smN03	66	4	grass	3	4
4/21/2016	20.1	12N	N/A	27.1	0	barberry	1	4
4/21/2016	20.1	12N	N/A	70.1	0	grass	3	4
4/21/2016	20.1	12N	N/A	23.9	0	barberry	1	4
4/21/2016	20.1	12N	smN04	101.9	8	barberry/rose	1	4
4/21/2016	20.1	12N	smN05	30.2	2	barberry	1	4
4/21/2016	20.1	12N	N/A	46.4	0	sparse barberry	1	4
4/21/2016	20.1	12N	smN06	18.2	4	leaf litter	0	4
4/21/2016	20.1	12N	N/A	52.5	0	barberry	1	4
4/21/2016	20.1	12N	N/A	47	0	leaf litter	0	4
5/19/2016	19.3	12N	smN01	100.1	1	invasive, ao	1	5
5/19/2016	19.3	12N	N/A	82.1	0	barberry	1	5

5/19/2016	19.3	12N	N/A	17.2	0	leaf litter	0	5
5/19/2016	19.3	12N	N/A	86.1	0	barberry	1	5
5/19/2016	19.3	12N	N/A	14.2	0	leaf litter	0	5
5/19/2016	19.3	12N	smN02	66.6	1	grass	3	5
5/19/2016	19.3	12N	N/A	34.1	0	barberry	1	5
5/19/2016	19.3	12N	N/A	70.1	0	grass	3	5
5/19/2016	19.3	12N	N/A	29.2	0	barberry	1	5
5/19/2016	19.3	12N	N/A	100.1	0	barberry/rose	1	5
5/19/2016	19.3	12N	N/A	30.4	0	barberry	1	5
5/19/2016	19.3	12N	N/A	46.1	0	sparse barberry	1	5
5/19/2016	19.3	12N	N/A	18.1	0	leaf litter	0	5
5/19/2016	19.3	12N	smN03	53.1	1	barberry	1	5
5/19/2016	19.3	12N	N/A	47.1	0	leaf litter	0	5
9/26/2016	19.9	12N	N/A	100.9	0	invasive, ao	1	1
9/26/2016	19.9	12N	N/A	82.3	0	barberry	1	1
9/26/2016	19.9	12N	N/A	15.2	0	leaf litter	0	1
9/26/2016	19.9	12N	N/A	85.2	0	barberry	1	1
9/26/2016	19.9	12N	N/A	15.3	0	leaf litter	0	1
9/26/2016	19.9	12N	N/A	67.4	0	grass	3	1
9/26/2016	19.9	12N	N/A	31.9	0	barberry	1	1
9/26/2016	19.9	12N	N/A	39.7	0	grass	3	1
9/26/2016	19.9	12N	N/A	29.2	0	barberry	1	1
9/26/2016	19.9	12N	N/A	98.7	0	barberry/rose	1	1
9/26/2016	19.9	12N	N/A	29.9	0	barberry	1	1
9/26/2016	19.9	12N	N/A	43.6	0	sparse barberry	1	1
9/26/2016	19.9	12N	N/A	16.4	0	leaf litter	0	1
9/26/2016	19.9	12N	N/A	51.4	0	barberry	1	1
9/26/2016	19.9	12N	N/A	46.4	0	leaf litter	0	1
10/5/2016	19.4	12N	N/A	100.7	0	invasive, ao	1	2
10/5/2016	19.4	12N	smN01	79.6	2	barberry	1	2
10/5/2016	19.4	12N	smN02	17.9	3	leaf litter	0	2
10/5/2016	19.4	12N	smN03	86.7	2	barberry	1	2
10/5/2016	19.4	12N	smN04	11.9	1	leaf litter	0	2
10/5/2016	19.4	12N	smN05	64.3	5	grass	3	2
10/5/2016	19.4	12N	smN06	33.7	2	barberry	1	2
10/5/2016	19.4	12N	smN07	67.8	6	grass	3	2
10/5/2016	19.4	12N	smN08	29.1	2	barberry	1	2
10/5/2016	19.4	12N	smN09	101.2	3	barberry/rose	1	2
10/5/2016	19.4	12N	smN10	30.3	1	barberry	1	2
10/5/2016	19.4	12N	N/A	46.1	0	sparse barberry	1	2
10/5/2016	19.4	12N	N/A	16.9	0	leaf litter	0	2
10/5/2016	19.4	12N	smN11	53.3	2	barberry	1	2
10/5/2016	19.4	12N	smN12	47.7	1	leaf litter	0	2

10/12/2016	19.4	12N	N/A	100.9	0	invasive, ao	1	3
10/12/2016	19.4	12N	smN01	80.4	3	barberry	1	3
10/12/2016	19.4	12N	smN02	18.3	2	leaf litter	0	3
10/12/2016	19.4	12N	smN03	88.1	1	barberry	1	3
10/12/2016	19.4	12N	N/A	14.3	0	leaf litter	0	3
10/12/2016	19.4	12N	smN04	65.9	5	grass	3	3
10/12/2016	19.4	12N	smN05	32.9	2	barberry	1	3
10/12/2016	19.4	12N	smN06	69.4	3	grass	3	3
10/12/2016	19.4	12N	smN07	26.8	4	barberry	1	3
10/12/2016	19.4	12N	smN08	98.1	3	barberry/rose	1	3
10/12/2016	19.4	12N	smN09	30.4	2	barberry	1	3
10/12/2016	19.4	12N	smN10	47.6	4	sparse barberry	1	3
10/12/2016	19.4	12N	smN11	18.9	3	leaf litter	0	3
10/12/2016	19.4	12N	smN12	55	2	barberry	1	3
10/12/2016	19.4	12N	smN13	48.1	1	leaf litter	0	3
10/17/2016	23.5	12N	smN01	100.4	3	invasive, ao	1	4
10/17/2016	23.5	12N	smN02	79.8	4	barberry	1	4
10/17/2016	23.5	12N	smN03	17.3	2	leaf litter	0	4
10/17/2016	23.5	12N	smN04	86.1	1	barberry	1	4
10/17/2016	23.5	12N	smN05	14.6	2	leaf litter	0	4
10/17/2016	23.5	12N	smN06	67	3	grass	3	4
10/17/2016	23.5	12N	smN07	33.3	4	barberry	1	4
10/17/2016	23.5	12N	smN08	71.6	2	grass	3	4
10/17/2016	23.5	12N	smN09	29.1	6	barberry	1	4
10/17/2016	23.5	12N	N/A	100.7	0	barberry/rose	1	4
10/17/2016	23.5	12N	smN10	28.2	2	barberry	1	4
10/17/2016	23.5	12N	smN11	45.3	1	sparse barberry	1	4
10/17/2016	23.5	12N	smN12	17.7	2	leaf litter	0	4
10/17/2016	23.5	12N	smN13	52.6	2	barberry	1	4
10/17/2016	23.5	12N	N/A	46.9	0	leaf litter	0	4
10/22/2016	16.8	12N	smN01	97.4	1	invasive, ao	1	5
10/22/2016	16.8	12N	smN02	82.4	1	barberry	1	5
10/22/2016	16.8	12N	smN03	15.3	2	leaf litter	0	5
10/22/2016	16.8	12N	smN04	87.8	3	barberry	1	5
10/22/2016	16.8	12N	smN05	14.7	3	leaf litter	0	5
10/22/2016	16.8	12N	smN06	65.1	5	grass	3	5
10/22/2016	16.8	12N	smN07	36.2	2	barberry	1	5
10/22/2016	16.8	12N	smN08	67.4	6	grass	3	5
10/22/2016	16.8	12N	smN09	30.5	3	barberry	1	5
10/22/2016	16.8	12N	smN10	97.6	5	barberry/rose	1	5
10/22/2016	16.8	12N	smN11	29.2	4	barberry	1	5
10/22/2016	16.8	12N	smN12	45.6	3	sparse barberry	1	5
10/22/2016	16.8	12N	smN13	17.2	6	leaf litter	0	5

10/22/2016	16.8	12N	smN14	54.5	3	barberry	1	5
10/22/2016	16.8	12N	smN15	46.9	5	leaf litter	0	5
5/12/2016	25.5	N/A	20	100.5	0	barberry	1	1
5/12/2016	25.5	sm2001	20	60.5	1	barberry	1	1
5/12/2016	25.5	sm2002	20	24.2	3	leaf litter	0	1
5/12/2016	25.5	N/A	20	15.3	0	barberry	1	1
5/12/2016	25.5	sm2003	20	76.9	1	grass	3	1
5/12/2016	25.5	sm2004	20	32.3	2	grass	3	1
5/12/2016	25.5	N/A	20	100.8	0	barberry	1	1
5/12/2016	25.5	N/A	20	100.0	0	barberry	1	1
5/12/2016	25.5	sm2005	20	16.7	1	leaf litter	0	1
5/12/2016	25.5	N/A	20	83.7	0	barberry	1	1
5/12/2016	25.5	N/A	20	101.9	0	barberry	1	1
5/12/2016	25.5	N/A	20	65.0	0	barberry	1	1
5/12/2016	25.5	N/A	20	34.2	0	grass	3	1
5/12/2016	25.5	N/A	20	19.5	0	grass	3	1
5/12/2016	25.5	N/A	20	80.9	0	barberry	1	1
5/12/2016	25.5	N/A	20	98.7	0	barberry	1	1
5/18/2016	20.6	N/A	20	100.5	0	barberry	1	2
5/18/2016	20.6	sm2006	20	59.8	3	barberry	1	2
5/18/2016	20.6	N/A	20	22.8	0	leaf litter	0	2
5/18/2016	20.6	sm2007	20	16.1	2	barberry	1	2
5/18/2016	20.6	N/A	20	100.8	0	grass	3	2
5/18/2016	20.6	N/A	20	101.9	0	barberry	1	2
5/18/2016	20.6	sm2008	20	99.2	3	barberry	1	2
5/18/2016	20.6	N/A	20	16.8	0	leaf litter	0	2
5/18/2016	20.6	N/A	20	83.8	0	barberry	1	2
5/18/2016	20.6	N/A	20	100.5	0	barberry	1	2
5/18/2016	20.6	N/A	20	58.7	0	barberry	1	2
5/18/2016	20.6	N/A	20	41.0	0	grass	3	2
5/18/2016	20.6	N/A	20	19.4	0	grass	3	2
5/18/2016	20.6	N/A	20	81.1	0	barberry	1	2
5/20/2016	23.9	sm2009	20	99.2	1	barberry	1	3
5/20/2016	23.9	N/A	20	59.6	0	barberry	1	3
5/20/2016	23.9	N/A	20	21.9	0	leaf litter	0	3
5/20/2016	23.9	N/A	20	17.0	0	barberry	1	3
5/20/2016	23.9	N/A	20	99.3	0	grass	3	3
5/20/2016	23.9	N/A	20	101.9	0	barberry	1	3
5/20/2016	23.9	N/A	20	98.9	0	barberry	1	3
5/20/2016	23.9	N/A	20	16.5	0	leaf litter	0	3
5/20/2016	23.9	N/A	20	83.9	0	barberry	1	3
5/20/2016	23.9	N/A	20	99.4	0	barberry	1	3
5/20/2016	23.9	sm2010	20	59.7	2	barberry	1	3

5/20/2016	23.9	N/A	20	39.5	0	grass	3	3
5/20/2016	23.9	N/A	20	20.1	0	grass	3	3
5/20/2016	23.9	N/A	20	81.8	0	barberry	1	3
5/20/2016	23.9	N/A	20	100.5	0	barberry	1	3
9/27/2016	21.3	N/A	20	100.9	0	barberry	1	1
9/27/2016	21.3	N/A	20	61.9	0	barberry	1	1
9/27/2016	21.3	N/A	20	23.4	0	leaf litter	0	1
9/27/2016	21.3	N/A	20	16.2	0	barberry	1	1
9/27/2016	21.3	N/A	20	86.2	0	grass	3	1
9/27/2016	21.3	N/A	20	101.9	0	barberry	1	1
9/27/2016	21.3	N/A	20	100.9	0	barberry	1	1
9/27/2016	21.3	N/A	20	16.5	0	leaf litter	0	1
9/27/2016	21.3	N/A	20	83.9	0	barberry	1	1
9/27/2016	21.3	N/A	20	101.0	0	barberry	1	1
9/27/2016	21.3	N/A	20	59.9	0	barberry	1	1
9/27/2016	21.3	N/A	20	39.4	0	grass	3	1
9/27/2016	21.3	N/A	20	20.1	0	grass	3	1
9/27/2016	21.3	N/A	20	81.8	0	barberry	1	1
9/27/2016	21.3	N/A	20	100.4	0	barberry	1	1
10/5/2016	18.7	smgd01	20	99.8	6	barberry	1	2
10/5/2016	18.7	smgd02	20	61.3	7	barberry	1	2
10/5/2016	18.7	smgd03	20	22.7	1	leaf litter	0	2
10/5/2016	18.7	smgd04	20	16.2	2	barberry	1	2
10/5/2016	18.7	smgd05	20	100.2	3	grass	3	2
10/5/2016	18.7	smgd06	20	98.4	1	barberry	1	2
10/5/2016	18.7	N/A	20	100.4	0	barberry	1	2
10/5/2016	18.7	N/A	20	16.5	0	leaf litter	0	2
10/5/2016	18.7	N/A	20	84.0	0	barberry	1	2
10/5/2016	18.7	smgd07	20	99.6	2	barberry	1	2
10/5/2016	18.7	smgd08	20	61.2	3	barberry	1	2
10/5/2016	18.7	N/A	20	20.2	0	grass	3	2
10/5/2016	18.7	N/A	20	81.9	0	barberry	1	2
10/5/2016	18.7	N/A	20	100.4	0	barberry	1	2
10/12/2016	16.4	smgd01	20	101.2	2	barberry	1	3
10/12/2016	16.4	N/A	20	62.0	0	barberry	1	3
10/12/2016	16.4	smgd02	20	21.1	3	leaf litter	0	3
10/12/2016	16.4	smgd03	20	16.1	5	barberry	1	3
10/12/2016	16.4	smgd04	20	100.7	4	grass	3	3
10/12/2016	16.4	N/A	20	100.1	0	barberry	1	3
10/12/2016	16.4	smgd05	20	100.2	2	barberry	1	3
10/12/2016	16.4	smgd06	20	16.5	4	leaf litter	0	3
10/12/2016	16.4	N/A	20	84.0	0	barberry	1	3
10/12/2016	16.4	smgd07	20	99.6	3	barberry	1	3

10/12/2016	16.4	smgd08	20	62.4	6	barberry	1	3
10/12/2016	16.4	smgd09	20	39.5	1	grass	3	3
10/12/2016	16.4	smgd10	20	20.2	2	grass	3	3
10/12/2016	16.4	smgd11	20	81.9	2	barberry	1	3
10/12/2016	16.4	N/A	20	100.4	0	barberry	1	3
10/16/2016	18.6	N/A	20	99.9	0	barberry	1	4
10/16/2016	18.6	smgd01	20	59.3	1	barberry	1	4
10/16/2016	18.6	smgd02	20	22.2	3	leaf litter	0	4
10/16/2016	18.6	smgd03	20	16.1	2	barberry	1	4
10/16/2016	18.6	N/A	20	100.9	0	grass	3	4
10/16/2016	18.6	smgd04	20	98.4	6	barberry	1	4
10/16/2016	18.6	smgd05	20	100.4	2	barberry	1	4
10/16/2016	18.6	N/A	20	16.5	0	leaf litter	0	4
10/16/2016	18.6	smgd06	20	84.0	3	barberry	1	4
10/16/2016	18.6	smgd07	20	99.6	2	barberry	1	4
10/16/2016	18.6	smgd08	20	58.0	7	barberry	1	4
10/16/2016	18.6	smgd09	20	41.3	2	grass	3	4
10/16/2016	18.6	smgd10	20	20.2	3	grass	3	4
10/16/2016	18.6	smgd11	20	81.9	4	barberry	1	4
10/16/2016	18.6	smgd12	20	100.4	2	barberry	1	4
10/23/2016	13.4	smgd01	20	98.8	5	barberry	1	5
10/23/2016	13.4	smgd02	20	62.9	2	barberry	1	5
10/23/2016	13.4	smgd03	20	21.6	3	leaf litter	0	5
10/23/2016	13.4	N/A	20	15.0	0	barberry	1	5
10/23/2016	13.4	smgd04	20	99.9	2	grass	3	5
10/23/2016	13.4	smgd05	20	99.2	3	barberry	1	5
10/23/2016	13.4	N/A	20	100.4	0	barberry	1	5
10/23/2016	13.4	smgd06	20	16.5	6	leaf litter	0	5
10/23/2016	13.4	smgd07	20	84.0	1	barberry	1	5
10/23/2016	13.4	smgd08	20	99.6	2	barberry	1	5
10/23/2016	13.4	smgd09	20	59.2	4	barberry	1	5
10/23/2016	13.4	smgd10	20	40.9	2	grass	3	5
10/23/2016	13.4	smgd11	20	20.2	7	grass	3	5
10/23/2016	13.4	smgd12	20	81.9	2	barberry	1	5
10/23/2016	13.4	smgd13	20	100.4	1	barberry	1	5
3/17/2016	16.8	N/A	3	100	0	native shrub	2	1
3/17/2016	16.8	N/A	3	101.2	0	native shrub	2	1
3/17/2016	16.8	N/A	3	99.8	0	native shrub	2	1
3/17/2016	16.8	smT01	3	99.9	1	native shrub	2	1
3/17/2016	16.8	N/A	3	100	0	native shrub	2	1
3/17/2016	16.8	N/A	3	102.2	0	native shrub	2	1
3/17/2016	16.8	N/A	3	102.1	0	native shrub	2	1
3/31/2016	20.7	N/A	3	98	0	native shrub	2	2

3/31/2016	20.7	N/A	3	100.2	0	native shrub	2	2
3/31/2016	20.7	N/A	3	98.8	0	native shrub	2	2
3/31/2016	20.7	N/A	3	99.9	0	native shrub	2	2
3/31/2016	20.7	N/A	3	99	0	native shrub	2	2
3/31/2016	20.7	N/A	3	101.2	0	native shrub	2	2
3/31/2016	20.7	N/A	3	101.5	0	native shrub	2	2
4/14/2016	13.8	N/A	3	99.3	0	native shrub	2	3
4/14/2016	13.8	N/A	3	100.6	0	native shrub	2	3
4/14/2016	13.8	N/A	3	98.4	0	native shrub	2	3
4/14/2016	13.8	N/A	3	99.5	0	native shrub	2	3
4/14/2016	13.8	smT01	3	99.2	1	native shrub	2	3
4/14/2016	13.8	N/A	3	101.8	0	native shrub	2	3
4/14/2016	13.8	N/A	3	101.1	0	native shrub	2	3
4/28/2016	15	smT01	3	100.1	1	native shrub	2	4
4/28/2016	15	N/A	3	100.2	0	native shrub	2	4
4/28/2016	15	N/A	3	99.8	0	native shrub	2	4
4/28/2016	15	N/A	3	99.9	0	native shrub	2	4
4/28/2016	15	N/A	3	100.1	0	native shrub	2	4
4/28/2016	15	N/A	3	100.2	0	native shrub	2	4
4/28/2016	15	N/A	3	100.1	0	native shrub	2	4
5/14/2016	22.2	N/A	3	100	0	native shrub	2	5
5/14/2016	22.2	N/A	3	100.1	0	native shrub	2	5
5/14/2016	22.2	smT01	3	100.3	1	native shrub	2	5
5/14/2016	22.2	N/A	3	99.2	0	native shrub	2	5
5/14/2016	22.2	N/A	3	100	0	native shrub	2	5
5/14/2016	22.2	N/A	3	100.1	0	native shrub	2	5
5/14/2016	22.2	N/A	3	102.1	0	native shrub	2	5
9/26/2016	20.8	N/A	3	100.2	0	native shrub	2	1
9/26/2016	20.8	N/A	3	99.8	0	native shrub	2	1
9/26/2016	20.8	N/A	3	100.1	0	native shrub	2	1
9/26/2016	20.8	N/A	3	99.9	0	native shrub	2	1
9/26/2016	20.8	N/A	3	100.3	0	native shrub	2	1
9/26/2016	20.8	N/A	3	100.1	0	native shrub	2	1
9/26/2016	20.8	N/A	3	100.1	0	native shrub	2	1
10/3/2016	19.4	N/A	3	99.7	0	native shrub	2	2
10/3/2016	19.4	N/A	3	99.2	0	native shrub	2	2
10/3/2016	19.4	N/A	3	100	0	native shrub	2	2
10/3/2016	19.4	N/A	3	100.2	0	native shrub	2	2
10/3/2016	19.4	smT01	3	100.3	1	native shrub	2	2
10/3/2016	19.4	N/A	3	100	0	native shrub	2	2
10/3/2016	19.4	N/A	3	99.9	0	native shrub	2	2
10/10/2016	12.4	N/A	3	99.1	0	native shrub	2	3
10/10/2016	12.4	N/A	3	99.3	0	native shrub	2	3

10/10/2016	12.4	N/A	3	100.1	0	native shrub	2	3
10/10/2016	12.4	N/A	3	99.8	0	native shrub	2	3
10/10/2016	12.4	N/A	3	100.1	0	native shrub	2	3
10/10/2016	12.4	N/A	3	100.2	0	native shrub	2	3
10/10/2016	12.4	N/A	3	101.1	0	native shrub	2	3
10/15/2016	15.7	N/A	3	100	0	native shrub	2	4
10/15/2016	15.7	N/A	3	99.2	0	native shrub	2	4
10/15/2016	15.7	N/A	3	100.2	0	native shrub	2	4
10/15/2016	15.7	N/A	3	99.8	0	native shrub	2	4
10/15/2016	15.7	N/A	3	99.3	0	native shrub	2	4
10/15/2016	15.7	N/A	3	100.2	0	native shrub	2	4
10/15/2016	15.7	N/A	3	99.4	0	native shrub	2	4
10/21/2016	18.6	N/A	3	99.8	0	native shrub	2	5
10/21/2016	18.6	N/A	3	100.1	0	native shrub	2	5
10/21/2016	18.6	N/A	3	99.8	0	native shrub	2	5
10/21/2016	18.6	N/A	3	99.2	0	native shrub	2	5
10/21/2016	18.6	N/A	3	100.1	0	native shrub	2	5
10/21/2016	18.6	N/A	3	100	0	native shrub	2	5
10/21/2016	18.6	smT01	3	100.3	1	native shrub	2	5
3/25/2016	21.2	N/A	12GT	69.2	0	leaf litter	0	1
3/25/2016	21.2	smgt01	12GT	23.9	1	barberry	1	1
3/25/2016	21.2	N/A	12GT	67.2	0	raspberry/grass	2	1
3/25/2016	21.2	smgt02	12GT	49.3	4	barberry	1	1
3/25/2016	21.2	N/A	12GT	43.4	0	leaf litter	0	1
3/25/2016	21.2	N/A	12GT	57.5	0	grass	3	1
3/25/2016	21.2	N/A	12GT	99.2	0	barberry/invasive	1	1
3/25/2016	21.2	N/A	12GT	29.3	0	rose	1	1
3/25/2016	21.2	N/A	12GT	70.2	0	barberry	1	1
3/25/2016	21.2	N/A	12GT	17.2	0	barberry	1	1
3/25/2016	21.2	N/A	12GT	84.4	0	leaf litter	0	1
3/25/2016	21.2	smgt03	12GT	101.2	3	barberry	1	1
3/25/2016	21.2	smgt04	12GT	67.8	1	barberry	1	1
3/25/2016	21.2	N/A	12GT	33.2	0	grass/raspberry	2	1
3/25/2016	21.2	N/A	12GT	98.8	0	barberry	1	1
3/25/2016	21.2	N/A	12GT	72.5	0	grass	3	1
3/25/2016	21.2	N/A	12GT	28.5	0	raspberry	1	1
4/15/2016	15.6	N/A	12GT	71.5	0	leaf litter	0	2
4/15/2016	15.6	N/A	12GT	24.1	0	barberry	1	2
4/15/2016	15.6	smgt01	12GT	66.3	3	raspberry/grass	2	2
4/15/2016	15.6	N/A	12GT	49.0	0	barberry	1	2
4/15/2016	15.6	N/A	12GT	41.8	0	leaf litter	0	2
4/15/2016	15.6	N/A	12GT	57.2	0	grass	3	2
4/15/2016	15.6	N/A	12GT	100.1	0	barberry/invasive	1	2

4/15/2016	15.6	smgt02	12GT	31.8	1	rose	1	2
4/15/2016	15.6	smgt03	12GT	69.7	4	barberry	1	2
4/15/2016	15.6	N/A	12GT	16.3	0	barberry	1	2
4/15/2016	15.6	N/A	12GT	86.5	0	leaf litter	0	2
4/15/2016	15.6	smgt04	12GT	100.0	1	barberry	1	2
4/15/2016	15.6	N/A	12GT	68.3	0	barberry	1	2
4/15/2016	15.6	N/A	12GT	33.8	0	grass/raspberry	2	2
4/15/2016	15.6	smgt05	12GT	98.8	2	barberry	1	2
4/15/2016	15.6	N/A	12GT	74.1	0	grass	3	2
4/15/2016	15.6	N/A	12GT	29.2	0	raspberry	1	2
4/17/2016	22.1	smgt01	12GT	70.2	1	leaf litter	0	3
4/17/2016	22.1	N/A	12GT	25.9	0	barberry	1	3
4/17/2016	22.1	N/A	12GT	68.2	0	raspberry/grass	2	3
4/17/2016	22.1	N/A	12GT	51.3	0	barberry	1	3
4/17/2016	22.1	N/A	12GT	42.4	0	leaf litter	0	3
4/17/2016	22.1	N/A	12GT	59.5	0	grass	3	3
4/17/2016	22.1	smgt02	12GT	100.2	2	barberry/invasive	1	3
4/17/2016	22.1	N/A	12GT	30.3	0	rose	1	3
4/17/2016	22.1	N/A	12GT	70.2	0	barberry	1	3
4/17/2016	22.1	N/A	12GT	16.2	0	barberry	1	3
4/17/2016	22.1	N/A	12GT	85.4	0	leaf litter	0	3
4/17/2016	22.1	smgt03	12GT	100.2	4	barberry	1	3
4/17/2016	22.1	N/A	12GT	68.2	0	barberry	1	3
4/17/2016	22.1	N/A	12GT	34.8	0	grass/raspberry	2	3
4/17/2016	22.1	N/A	12GT	97.8	0	barberry	1	3
4/17/2016	22.1	N/A	12GT	73.5	0	grass	3	3
4/17/2016	22.1	N/A	12GT	30.5	0	raspberry	1	3
4/21/2016	20.5	N/A	12GT	68.2	0	leaf litter	0	4
4/21/2016	20.5	smgt01	12GT	22.9	2	barberry	1	4
4/21/2016	20.5	N/A	12GT	66.2	0	raspberry/grass	2	4
4/21/2016	20.5	N/A	12GT	49.3	0	barberry	1	4
4/21/2016	20.5	N/A	12GT	43.4	0	leaf litter	0	4
4/21/2016	20.5	N/A	12GT	57.0	0	grass	3	4
4/21/2016	20.5	smgt02	12GT	100.2	6	barberry/invasive	1	4
4/21/2016	20.5	N/A	12GT	29.3	0	rose	1	4
4/21/2016	20.5	N/A	12GT	71.2	0	barberry	1	4
4/21/2016	20.5	smgt03	12GT	18.2	2	barberry	1	4
4/21/2016	20.5	N/A	12GT	83.4	0	leaf litter	0	4
4/21/2016	20.5	N/A	12GT	101.2	0	barberry	1	4
4/21/2016	20.5	N/A	12GT	68.0	0	barberry	1	4
4/21/2016	20.5	smgt04	12GT	32.0	3	grass/raspberry	2	4
4/21/2016	20.5	N/A	12GT	99.8	0	barberry	1	4
4/21/2016	20.5	N/A	12GT	71.5	0	grass	3	4

4/21/2016	20.5	N/A	12GT	28.5	0	raspberry	1	4
5/19/2016	20.3	N/A	12GT	68.1	0	leaf litter	0	5
5/19/2016	20.3	N/A	12GT	33.0	0	barberry	1	5
5/19/2016	20.3	N/A	12GT	67.1	0	raspberry/grass	2	5
5/19/2016	20.3	N/A	12GT	32.9	0	barberry	1	5
5/19/2016	20.3	N/A	12GT	44.0	0	leaf litter	0	5
5/19/2016	20.3	smgt01	12GT	56.9	1	grass	3	5
5/19/2016	20.3	N/A	12GT	100.1	0	barberry/invasive	1	5
5/19/2016	20.3	N/A	12GT	29.4	0	rose	1	5
5/19/2016	20.3	N/A	12GT	70.9	0	barberry	1	5
5/19/2016	20.3	N/A	12GT	18.3	0	barberry	1	5
5/19/2016	20.3	smgt02	12GT	83.4	1	leaf litter	0	5
5/19/2016	20.3	gmgt03	12GT	100.1	5	barberry	1	5
5/19/2016	20.3	N/A	12GT	67.5	0	barberry	1	5
5/19/2016	20.3	smgt04	12GT	33.1	1	grass/raspberry	2	5
5/19/2016	20.3	smgt05	12GT	100.1	4	barberry	1	5
5/19/2016	20.3	N/A	12GT	71.3	0	grass	3	5
5/19/2016	20.3	N/A	12GT	28.5	0	raspberry	1	5
9/26/2016	20.4	N/A	12GT	67.2	0	leaf litter	0	1
9/26/2016	20.4	N/A	12GT	32.8	0	barberry	1	1
9/26/2016	20.4	N/A	12GT	70.4	0	raspberry	2	1
9/26/2016	20.4	N/A	12GT	29.6	0	barberry	1	1
9/26/2016	20.4	N/A	12GT	37.3	0	leaf litter	0	1
9/26/2016	20.4	N/A	12GT	62.7	0	grass	3	1
9/26/2016	20.4	N/A	12GT	99.4	0	barberry/invasive	1	1
9/26/2016	20.4	N/A	12GT	28.9	0	rose	1	1
9/26/2016	20.4	N/A	12GT	71.2	0	barberry	1	1
9/26/2016	20.4	N/A	12GT	23.4	0	barberry	1	1
9/26/2016	20.4	N/A	12GT	76.6	0	leaf litter	0	1
9/26/2016	20.4	N/A	12GT	99.8	0	barberry	1	1
9/26/2016	20.4	N/A	12GT	66.4	0	barberry	1	1
9/26/2016	20.4	N/A	12GT	33.6	0	grass/raspberry	2	1
9/26/2016	20.4	N/A	12GT	98.7	0	barberry	1	1
9/26/2016	20.4	N/A	12GT	72.4	0	grass	3	1
9/26/2016	20.4	N/A	12GT	28.4	0	raspberry	1	1
10/4/2016	17.3	smgt01	12GT	64.7	3	leaf litter	0	2
10/4/2016	17.3	smgt02	12GT	36.8	2	barberry	1	2
10/4/2016	17.3	smgt03	12GT	65.0	2	raspberry	2	2
10/4/2016	17.3	smgt04	12GT	36.4	4	barberry	1	2
10/4/2016	17.3	smgt05	12GT	43.3	1	leaf litter	0	2
10/4/2016	17.3	smgt06	12GT	55.1	6	grass	3	2
10/4/2016	17.3	N/A	12GT	100.7	0	barberry/invasive	1	2
10/4/2016	17.3	N/A	12GT	30.9	0	rose	1	2

10/4/2016	17.3	smgt07	12GT	73.8	6	barberry	1	2
10/4/2016	17.3	smgt08	12GT	21.3	5	barberry	1	2
10/4/2016	17.3	smgt09	12GT	86.0	4	leaf litter	0	2
10/4/2016	17.3	smgt10	12GT	100.0	2	barberry	1	2
10/4/2016	17.3	N/A	12GT	62.4	0	barberry	1	2
10/4/2016	17.3	smgt11	12GT	35.4	2	grass/raspberry	2	2
10/4/2016	17.3	smgt12	12GT	99.5	4	barberry	1	2
10/4/2016	17.3	smgt13	12GT	72.7	6	grass	3	2
10/4/2016	17.3	smgt14	12GT	30.5	2	raspberry	1	2
10/11/2016	15.9	smgt01	12GT	67.5	7	leaf litter	0	3
10/11/2016	15.9	smgt02	12GT	37.9	4	barberry	1	3
10/11/2016	15.9	smgt03	12GT	69.3	3	raspberry/grass	2	3
10/11/2016	15.9	smgt04	12GT	35.5	2	barberry	1	3
10/11/2016	15.9	smgt05	12GT	44.1	4	leaf litter	0	3
10/11/2016	15.9	smgt06	12GT	55.4	6	grass	3	3
10/11/2016	15.9	smgt07	12GT	100.3	3	barberry/invasive	1	3
10/11/2016	15.9	smgt08	12GT	28.3	1	rose	1	3
10/11/2016	15.9	smgt09	12GT	71.1	4	barberry	1	3
10/11/2016	15.9	smgt10	12GT	18.8	5	barberry	1	3
10/11/2016	15.9	smgt11	12GT	82.5	2	leaf litter	0	3
10/11/2016	15.9	smgt12	12GT	98.5	2	barberry	1	3
10/11/2016	15.9	smgt13	12GT	61.2	3	barberry	1	3
10/11/2016	15.9	smgt14	12GT	37.8	2	grass/raspberry	2	3
10/11/2016	15.9	smgt15	12GT	98.5	4	barberry	1	3
10/11/2016	15.9	smgt16	12GT	71.4	8	grass	3	3
10/11/2016	15.9	smgt17	12GT	30.9	3	raspberry	1	3
10/15/2016	16.1	smgt01	12GT	66.4	5	leaf litter	0	4
10/15/2016	16.1	smgt02	12GT	35.1	2	barberry	1	4
10/15/2016	16.1	smgt03	12GT	61.9	1	raspberry/grass	2	4
10/15/2016	16.1	N/A	12GT	36.4	0	barberry	1	4
10/15/2016	16.1	smgt04	12GT	43.0	2	leaf litter	0	4
10/15/2016	16.1	smgt05	12GT	56.2	3	grass	3	4
10/15/2016	16.1	smgt06	12GT	99.2	2	barberry/invasive	1	4
10/15/2016	16.1	N/A	12GT	28.7	0	rose	1	4
10/15/2016	16.1	smgt07	12GT	74.1	5	barberry	1	4
10/15/2016	16.1	smgt08	12GT	21.2	5	barberry	1	4
10/15/2016	16.1	smgt09	12GT	84.3	2	leaf litter	0	4
10/15/2016	16.1	N/A	12GT	98.3	0	barberry	1	4
10/15/2016	16.1	smgt10	12GT	64.8	2	barberry	1	4
10/15/2016	16.1	N/A	12GT	35.8	0	grass/raspberry	2	4
10/15/2016	16.1	smgt11	12GT	98.8	6	barberry	1	4
10/15/2016	16.1	smgt12	12GT	73.4	8	grass	3	4
10/15/2016	16.1	N/A	12GT	30.8	0	raspberry	1	4

10/22/2016	15.5	smgt01	12GT	62.7	8	leaf litter	0	5
10/22/2016	15.5	smgt02	12GT	35.8	2	barberry	1	5
10/22/2016	15.5	smgt03	12GT	65.9	1	raspberry/grass	2	5
10/22/2016	15.5	smgt04	12GT	34.3	4	barberry	1	5
10/22/2016	15.5	smgt05	12GT	44.7	5	leaf litter	0	5
10/22/2016	15.5	smgt06	12GT	56.6	3	grass	3	5
10/22/2016	15.5	N/A	12GT	98.5	0	barberry/invasive	1	5
10/22/2016	15.5	N/A	12GT	30.2	0	rose	1	5
10/22/2016	15.5	smgt07	12GT	73.7	2	barberry	1	5
10/22/2016	15.5	smgt08	12GT	19.5	4	barberry	1	5
10/22/2016	15.5	smgt09	12GT	82.5	2	leaf litter	0	5
10/22/2016	15.5	smgt10	12GT	100.2	6	barberry	1	5
10/22/2016	15.5	smgt11	12GT	69.0	3	barberry	1	5
10/22/2016	15.5	N/A	12GT	37.2	0	grass/raspberry	2	5
10/22/2016	15.5	smgt12	12GT	99.8	4	barberry	1	5
10/22/2016	15.5	N/A	12GT	72.2	0	grass	3	5
10/22/2016	15.5	smgt13	12GT	29.4	2	raspberry	1	5

APPENDIX 3: Tick data from New England and eastern cottontails in New York. IS = *Ixodes scapularis,* ID = *Ixodes dentatus,* DV = *Dermacentor variabilis,* RS = *Rhipicephalus sanguineus,* and HL = *Haemaphysalis leporispalustris.*

Date	Site	CODE	TAG	WT	GSpps	Age	Ticks	VIAL	UNK	IS	ID	DV	RS	HL
4/10/2014	6	6	NA	1120	0	3	1	0	0	0	0	0	0	0
5/28/2014	12N	15	528	1130	0	3	0	0	0	0	0	0	0	0
5/30/2014	12GT	14	530	1265	0	3	1	0	0	0	0	0	0	0
7/25/2014	4	4	538	275	0	1	1	0	0	0	0	0	0	0
7/29/2014	6	6	539	290	0	1	23	0	10	8	0	0	0	2
8/5/2014	7	7	543	750	0	2	0	2	0	0	0	0	2	0
8/8/2014	4	4	548	830	0	3	0	0	0	0	0	0	0	0
8/12/2014	6	6	539	390	0	1	4	0	0	0	0	0	0	0
9/23/2014	6	6	560	1070	0	3	5	0	0	2	0	0	0	1
10/9/2014	2	2	563	860	0	NA	2	0	0	0	0	0	0	0
10/16/2014	6	6	564	1025	0	3	0	0	0	0	0	0	0	0
10/21/2014	2	2	568	1115	0	3	3	0	0	0	0	0	0	0
10/23/2014	12N	15	570	1225	0	3	4	2	0	1	0	0	0	0
10/23/2014	12N	15	571	660	0	2	2	0	0	0	0	0	0	0
10/24/2014	12N	15	572	1080	0	3	1	0	0	0	0	0	0	0
11/4/2014	12N	15	575	745	0	2	24	12	0	8	1	0	0	3
11/5/2014	12	9	601	1085	0	2	4	0	0	0	0	0	0	0
12/18/2014	13	10	606	1265	0	3	26	0	0	0	0	0	0	0
1/6/2015	5	5	609	NA	0	3	9	0	0	7	2	0	0	1
1/16/2015	4	4	610	1225	0	3	9	0	0	6	1	0	0	1
1/20/2015	6	6	611	950	0	3	0	0	0	0	0	0	0	0
2/12/2015	4	4	612	1140	0	0	6	0	0	0	0	0	0	0
3/19/2015	13B	16	620	950	0	3	2	0	0	0	0	0	0	0
3/20/2015	13B	16	621	1015	0	3	0	0	0	0	0	0	0	0
3/25/2015	12	9	622	985	0	3	15	0	0	0	0	0	0	0
4/9/2015	12	9	629	880	0	3	20	14	0	8	3	0	3	0
4/9/2015	1	1	628	1185	0	3	10	0	0	0	0	0	0	0
4/10/2015	12	9	630	1080	0	3	3	0	0	0	0	0	0	0
4/15/2015	12	9	633	1270	0	3	12	0	0	0	0	0	0	0
4/16/2015	12	9	634	1110	0	3	6	10	0	8	2	0	0	0
5/8/2015	7	7	636	1390	0	3	9	0	0	0	0	0	0	0
5/15/2015	2	2	568	NA	0	3	0	6	1	4	0	0	0	1
5/22/2015	2	2	638	220	0	1	0	11	0	9	2	0	0	0
5/22/2015	4	4	637	190	0	1	0	0	0	0	0	0	0	0
5/29/2015	4	4	639	300	0	1	0	3	0	3	0	0	0	0
6/3/2015	12	9	640	310	0	1	18	5	0	4	1	0	0	0
6/3/2015	4	4	609	NA	0	3	0	5	0	0	5	0	0	0
6/3/2015	12	9	641	350	0	1	0	0	0	0	0	0	0	0
6/5/2015	12	9	642	255	0	1	21	1	0	1	0	0	0	0

6/9/2015	12	9	644	1370	0	3	1	3	0	1	0	0	0	0
6/9/2015	12	9	643	170	0	1	0	1	0	1	0	0	0	0
6/10/2015	12	9	645	425	0	2	2	0	0	0	0	0	0	0
6/11/2015	13B	16	646	1410	0	3	5	2	6	4	6	0	0	0
6/18/2015	12	9	649	455	0	NA	0	3	0	2	0	0	0	0
6/18/2015	12	9	650	380	0	NA	0	0	0	0	0	0	0	0
7/14/2015	1	1	652	785	0	2	1	5	0	3	2	0	0	0
8/14/2015	2	2	638	865	0	3	0	2	0	2	0	0	0	0
8/20/2015	2	2	656	965	0	3	8	0	0	0	0	0	0	0
8/26/2015	2	2	660	940	0	3	2	0	0	0	0	0	0	0
8/27/2015	4	4	662	985	0	3	11	8	0	8	0	0	0	0
8/28/2015	2	2	656	985	0	NA	1	0	0	0	0	0	0	0
8/28/2015	4	4	663	485	0	1	0	3	1	0	1	0	0	1
9/10/2015	12GT	14	650	945	0	3	6	0	0	0	0	0	0	0
9/10/2015	12GT	14	664	980	0	3	5	0	0	0	0	0	0	0
9/10/2015	12GT	14	643	940	0	3	1	2	1	1	0	0	0	0
9/10/2015	12GT	14	665	700	0	2	1	3	0	3	0	0	0	0
9/15/2015	12GT	14	668	850	0	3	4	0	0	0	0	0	0	0
9/15/2015	12GT	14	669	1125	0	3	3	0	0	0	0	0	0	0
9/15/2015	19	12	670	710	0	3	0	0	0	0	0	0	0	0
9/16/2015	12GT	14	671	705	0	2	5	0	0	0	0	0	0	0
9/17/2015	4	4	674	1230	0	3	4	0	0	0	0	0	0	0
9/17/2015	12GT	14	672	620	0	2	2	0	0	0	0	0	0	0
9/17/2015	4	4	673	905	0	3	0	1	0	0	0	0	0	1
9/17/2015	12GT	14	643	900	0	3	0	0	0	0	0	0	0	0
9/18/2015	4	4	675	950	0	3	1	1	0	0	0	0	0	1
9/18/2015	4	4	676	1110	0	3	1	0	0	0	0	0	0	0
9/18/2015	4	4	677	1390	0	3	0	2	2	0	0	0	0	0
9/22/2015	12N	15	678	265	0	1	11	9	0	6	3	0	0	0
9/22/2015	1	1	628	1300	0	3	2	2	0	1	1	0	0	0
10/13/2015	13B	16	685	1090	0	3	1	0	0	0	0	0	0	0
10/14/2015	8	8	686	1110	0	3	1	1	0	0	0	0	0	1
10/15/2015	13B	16	687	960	0	3	6	5	0	4	1	0	0	0
10/23/2015	13B	16	688	1010	0	3	0	0	0	0	0	0	0	0
10/27/2015	13B	16	646	1450	0	3	1	0	0	0	0	0	0	0
10/27/2015	13B	16	691	1170	0	3	0	1	0	1	0	0	0	0
10/28/2015	5	5	692	1290	0	3	17	10	0	0	9	1	0	0
11/11/2015	7	7	693	1040	0	3	1	0	0	0	0	0	0	0
11/12/2015	7	7	694	545	0	2	1	0	0	0	0	0	0	0
11/13/2015	7	7	695	1160	0	3	8	0	0	0	0	0	0	0
11/19/2015	7	7	697	1290	0	3	8	0	0	0	0	0	0	0
12/3/2015	7	7	694	770	0	2	1	0	0	0	0	0	0	0
12/13/2015	19	12	700	1090	0	3	2	0	0	0	0	0	0	0

12/14/2015	1	1	701	1190	0	3	12	8	0	7	0	0	0	1
12/16/2015	1	1	703	1290	0	3	14	5	0	5	0	0	0	0
12/21/2015	19	12	670	280	0	1	0	0	0	0	0	0	0	0
1/6/2016	2	2	705	1010	0	3	3	0	0	0	0	0	0	0
1/8/2016	2	2	706	1210	0	3	19	10	0	3	2	1	4	0
1/14/2016	13B	16	707	1260	0	3	26	13	0	13	0	0	0	0
1/15/2016	13B	16	708	1110	0	3	20	11	0	9	2	0	0	0
1/21/2016	2	2	709	1170	0	3	5	0	0	0	0	0	1	0
2/5/2016	6	6	710	1500	0	3	10	0	0	0	0	0	0	0
2/25/2016	6	6	712	1005	0	3	0	0	0	0	0	0	0	0
2/26/2016	20	13	713	975	0	3	7	0	0	0	0	0	0	0
3/11/2016	4	4	719	1285	0	3	1	0	0	0	0	0	0	0
5/18/2016	12GT	14	726	1490	0	3	0	0	0	0	0	0	0	0
5/19/2016	12GT	14	727	255	0	1	0	0	0	0	0	0	0	0
5/24/2016	12GT	14	728	1490	0	3	1	2	0	2	0	0	0	0
9/21/2016	8	8	746	1185	0	3	0	0	0	0	0	0	0	0
10/13/2016	8	8	754	1190	0	3	4	12	0	12	0	0	0	0
10/21/2016	20	13	756	530	0	1	3	0	0	0	0	0	0	0
1/9/2014	6	6	524	1150	1	3	0	0	0	0	0	0	0	0
1/10/2014	6	6	507	1125	1	3	0	0	0	0	0	0	0	0
1/14/2014	3	3	512	1265	1	3	19	0	0	0	0	0	0	0
2/4/2014	2	2	583	1295	1	3	2	0	0	0	0	0	0	0
2/12/2014	4	4	585	1290	1	3	22	0	0	0	0	0	0	0
2/21/2014	8	8	586	1210	1	3	1	0	0	0	0	0	0	0
5/13/2014	8	8	599	210	1	1	0	0	0	0	0	0	0	0
5/15/2014	3	3	600	1145	1	3	1	2	0	0	2	0	0	0
5/20/2014	4	4	526	910	1	3	2	0	0	0	0	0	0	0
5/27/2014	12N	15	527	1290	1	3	0	2	0	2	0	0	0	0
5/27/2014	12N	15	527	1290	1	3	0	4	0	4	0	0	0	0
5/28/2014	8	8	599	255	1	1	2	3	0	1	0	0	0	2
5/29/2014	8	8	529	335	1	1	0	0	0	0	0	0	0	0
6/4/2014	13	10	532	1090	1	3	1	0	0	0	0	0	0	0
6/4/2014	3	3	531	890	1	3	0	0	0	0	0	0	0	0
6/24/2014	5	5	533	470	1	2	3	0	0	0	0	0	0	0
6/24/2014	5	5	534	1190	1	3	0	0	0	0	0	0	0	0
6/25/2014	1	1	535	1120	1	3	0	0	0	0	0	0	0	0
6/27/2014	5	5	536	590	1	2	0	0	0	0	0	0	0	0
7/1/2014	7	7	537	980	1	3	5	9	0	8	0	0	0	0
7/31/2014	6	6	541	660	1	2	1	2	0	2	0	0	0	0
7/31/2014	6	6	540	690	1	2	0	2	0	2	0	0	0	0
8/5/2014	6	6	507	920	1	3	NA	4	0	3	0	0	0	1
8/6/2014	7	7	545	1045	1	3	1	0	0	0	0	0	0	0
8/7/2014	6	6	544	570	1	2	0	7	0	1	0	5	1	0

8/8/2014	4	4	547	725	1	2	4	0	0	0	0	0	0	0
8/8/2014	6	6	546	1010	1	3	3	1	0	1	0	0	0	0
8/8/2014	4	4	549	750	1	2	0	0	0	0	0	0	0	0
8/12/2014	6	6	551	1175	1	3	1	0	0	0	0	0	0	0
8/12/2014	6	6	544	335	1	1	0	0	0	0	0	0	0	0
8/13/2014	6	6	524	1235	1	3	0	1	0	1	0	0	0	0
8/15/2014	6	6	541	730	1	2	2	0	0	0	0	0	0	0
8/15/2014	4	4	552	125	1	1	0	0	0	0	0	0	0	0
8/19/2014	6	6	544	425	1	1	0	0	0	0	0	0	0	0
8/20/2014	2	2	555	260	1	1	0	0	0	0	0	0	0	0
8/21/2014	6	6	544	445	1	2	0	0	0	0	0	0	0	0
9/4/2014	2	2	556	435	1	1	0	0	0	0	0	0	0	0
9/5/2014	2	2	583	1200	1	3	6	0	0	0	0	0	0	0
9/10/2014	6	6	557	785	1	2	0	1	0	0	0	0	1	0
9/11/2014	6	6	544	420	1	1	NA	1	0	0	1	0	0	0
9/12/2014	6	6	551	1235	1	3	5	0	0	0	0	0	0	0
9/12/2014	2	2	559	940	1	2	0	2	2	0	0	0	0	0
9/16/2014	6	6	544	565	1	2	1	0	0	0	0	0	0	0
9/16/2014	6	6	551	1125	1	3	0	0	0	0	0	0	0	0
9/18/2014	6	6	551	1085	1	3	5	4	1	0	3	0	0	0
9/18/2014	2	2	553	500	1	1	2	0	0	0	0	0	0	0
9/19/2014	6	6	544	575	1	2	1	0	0	0	0	0	0	0
9/19/2014	2	2	553	260	1	1	0	0	0	0	0	0	0	0
9/19/2014	2	2	554	245	1	1	0	0	0	0	0	0	0	0
9/23/2014	2	2	556	405	1	1	0	1	0	1	0	0	0	0
9/23/2014	6	6	544	585	1	NA	0	0	0	0	0	0	0	0
9/24/2014	2	2	556	415	1	1	0	1	0	0	1	0	0	0
9/25/2014	2	2	553	510	1	1	2	1	0	0	1	0	0	0
9/26/2014	6	6	544	615	1	2	0	26	0	25	0	0	0	0
10/1/2014	2	2	554	375	1	1	2	0	0	0	0	0	0	0
10/1/2014	2	2	559	765	1	2	1	0	0	0	0	0	0	0
10/1/2014	6	6	562	245	1	1	0	2	0	1	0	0	0	0
10/2/2014	6	6	544	655	1	2	1	0	0	0	0	0	0	0
10/7/2014	6	6	561	185	1	1	0	8	0	7	0	1	0	0
10/8/2014	2	2	554	475	1	2	3	9	0	7	0	2	0	0
10/9/2014	6	6	561	245	1	1	0	0	0	0	0	0	0	0
10/14/2014	2	2	554	455	1	1	1	1	1	0	0	0	0	0
10/14/2014	2	2	559	935	1	2	1	0	0	0	0	0	0	0
10/14/2014	2	2	554	480	1	2	0	0	0	0	0	0	0	0
10/17/2014	6	6	551	1145	1	3	0	0	0	0	0	0	0	0
10/21/2014	12N	15	566	1115	1	3	15	0	0	0	0	0	0	0
10/21/2014	12N	15	567	945	1	3	0	0	0	0	0	0	0	0
10/22/2014	12N	15	569	640	1	1	2	11	0	9	2	0	0	0

10/24/2014	2	2	559	995	1	2	2	1	1	0	0	0	0	0
10/29/2014	12N	15	573	975	1	3	13	0	0	0	0	0	0	0
10/29/2014	3	3	574	835	1	2	3	0	0	0	0	0	0	0
11/7/2014	3	3	574	865	1	3	1	1	0	0	0	0	0	1
11/7/2014	12N	15	569	735	1	3	1	0	0	0	0	0	0	0
11/12/2014	3	3	574	895	1	3	0	0	0	0	0	0	0	0
11/19/2014	1	1	602	1055	1	3	3	0	0	0	0	0	0	0
11/20/2014	1	1	603	1030	1	3	3	0	0	0	0	0	0	0
11/24/2014	1	1	602	1190	1	3	1	0	0	0	0	0	0	0
12/17/2014	13	10	605	1105	1	3	16	0	0	0	0	0	0	0
12/19/2014	13	10	607	1050	1	3	7	0	0	0	0	0	0	0
12/31/2014	5	5	608	1170	1	3	18	0	0	0	0	0	0	0
1/20/2015	6	6	546	980	1	3	0	0	0	0	0	0	0	0
2/4/2015	6	6	546	630	1	2	6	0	0	0	0	0	0	0
2/25/2015	7	7	613	980	1	3	0	0	0	0	0	0	0	0
2/26/2015	4	4	542	990	1	3	1	0	0	0	0	0	0	0
3/3/2015	7	7	614	1020	1	3	5	0	0	0	0	0	0	0
3/3/2015	7	7	615	1100	1	3	0	0	0	0	0	0	0	0
3/10/2015	7	7	616	1145	1	3	1	0	0	0	0	0	0	0
3/12/2015	7	7	617	985	1	3	0	0	0	0	0	0	0	0
3/13/2015	7	7	618	965	1	3	1	0	0	0	0	0	0	0
3/17/2015	13B	16	619	869	1	3	4	0	0	0	0	0	0	0
4/7/2015	8	8	624	850	1	3	6	0	0	0	0	0	0	0
4/8/2015	1	1	626	1065	1	3	40	33	0	17	8	2	2	4
4/8/2015	1	1	625	980	1	3	17	6	0	6	0	0	0	0
4/8/2015	1	1	627	1045	1	3	2	0	0	0	0	0	0	0
10-Apr	1.00	1	602	990	1	3	3	0	0	0	0	0	0	0
4/13/2015	1	1	603	1185	1	3	7	0	0	0	0	0	0	0
4/14/2015	1	1	631	1090	1	3	2	0	0	0	0	0	0	0
4/22/2015	1	1	623	960	1	3	13	5	0	1	4	0	0	0
4/24/2015	1	1	602	1210	1	3	14	0	0	0	0	0	0	0
5/5/2015	7	7	635	1120	1	3	12	6	3	3	0	0	0	0
6/17/2015	12	9	648	1160	1	3	1	2	0	2	0	0	0	0
7/7/2015	8	8	651	585	1	2	1	0	0	0	0	0	0	0
7/14/2015	8	8	653	495	1	2	0	7	2	1	0	0	0	0
7/16/2015	1	1	655	450	1	1	2	4	0	4	0	0	0	0
8/21/2015	19	12	658	1305	1	3	6	1	0	0	0	0	0	1
8/21/2015	19	12	659	920	1	3	3	0	0	0	0	0	0	0
8/21/2015	19	12	657	880	1	3	1	1	0	1	0	0	0	0
8/26/2015	19	12	658	1390	1	3	13	0	0	0	0	0	0	0
8/26/2015	4	4	661	605	1	2	0	1	0	1	0	0	0	0
9/29/2015	8	8	679	870	1	3	4	0	0	0	0	0	0	0
9/29/2015	8	8	681	1080	1	3	3	0	0	0	0	0	0	0

9/29/2015	8	8	680	845	1	3	1	0	0	0	0	0	1	0
9/30/2015	8	8	586	1220	1	3	7	0	0	0	0	0	0	0
9/30/2015	19	12	657	1060	1	3	0	1	0	1	0	0	0	0
10/1/2015	12N	15	682	905	1	3	6	2	0	2	0	0	0	0
10/2/2015	19	12	658	1350	1	3	0	0	0	0	0	0	0	0
10/6/2015	8	8	683	890	1	3	0	1	0	1	0	0	0	0
10/7/2015	8	8	684	960	1	3	0	0	0	0	0	0	0	0
10/15/2015	8	8	586	1225	1	3	2	1	0	1	0	0	0	0
10/20/2015	3	3	689	810	1	3	1	0	0	0	0	0	0	0
10/21/2015	5	5	690	870	1	3	0	0	0	0	0	0	0	0
11/18/2015	7	7	696	1150	1	3	0	0	0	0	0	0	0	0
12/4/2015	18	11	698	1110	1	3	25	19	0	10	3	6	0	0
12/10/2015	18	11	698	1090	1	3	6	0	0	0	0	0	0	0
12/11/2015	19	12	658	1595	1	3	4	4	0	2	2	0	0	0
12/13/2015	1	1	699	1130	1	3	9	3	0	2	1	0	0	0
12/13/2015	1	1	602	1050	1	3	5	2	0	2	0	0	0	0
12/14/2015	1	1	654	500	1	1	1	0	0	0	0	0	0	0
12/15/2015	1	1	627	1020	1	3	7	5	0	0	5	0	0	0
12/15/2015	19	12	702	830	1	3	1	0	0	0	0	0	0	0
12/16/2015	1	1	704	1170	1	3	24	13	0	6	3	4	0	0
12/16/2015	1	1	602	1080	1	3	1	0	0	0	0	0	0	0
12/21/2015	1	1	654	1070	1	3	11	9	0	1	0	3	3	2
12/22/2015	1	1	627	1250	1	3	11	0	0	0	0	0	0	0
12/30/2015	1	1	627	1190	1	3	0	0	0	0	0	0	0	0
12/30/2015	1	1	699	1110	1	3	0	0	0	0	0	0	0	0
12/31/2015	19	12	658	1345	1	3	0	0	0	0	0	0	0	0
1/8/2016	1	1	699	1125	1	3	0	0	0	0	0	0	0	0
2/25/2016	20	13	711	940	1	3	16	0	0	0	0	0	0	0
3/3/2016	20	13	715	1000	1	3	11	5	0	5	0	0	0	0
3/4/2016	20	13	716	1115	1	3	21	0	0	0	0	0	0	0
3/11/2016	20	13	718	1030	1	3	6	7	2	5	0	0	0	0
3/11/2016	20	13	717	930	1	3	2	7	0	7	0	0	0	0
4/6/2016	12N	15	720	1100	1	3	22	0	0	0	0	0	0	0
4/6/2016	4	4	721	1220	1	3	3	10	0	10	0	0	0	0
4/7/2016	12N	15	722	1020	1	3	3	0	0	0	0	0	0	0
4/20/2016	8	8	725	1030	1	3	12	2	0	2	0	0	0	0
4/20/2016	8	8	724	1298	1	3	11	0	0	0	0	0	0	0
4/22/2016	12N	15	723	1410	1	3	8	3	0	3	0	0	0	0
4/22/2016	8	8	680	1190	1	3	2	0	0	0	0	0	0	0
8/19/2016	20	13	729	910	1	3	1	2	0	2	0	0	0	0
8/23/2016	8	8	730	920	1	3	6	0	0	0	0	0	0	0
8/24/2016	12N	15	731	925	1	3	2	1	0	0	0	0	0	1
8/24/2016	20	13	732	710	1	2	0	4	1	3	0	0	0	0

8/25/2016	8	8	733	425	1	1	10	3	0	2	0	0	0	1
8/30/2016	12N	15	734	835	1	3	12	0	0	0	0	0	0	0
8/31/2016	12N	15	735	1055	1	3	8	3	0	2	0	0	0	1
8/31/2016	8	8	737	590	1	2	4	1	0	0	0	1	0	0
8/31/2016	8	8	738	560	1	2	1	1	0	1	0	0	0	0
8/31/2016	12N	15	736	285	1	1	1	1	0	1	0	0	0	0
8/31/2016	8	8	739	1050	1	3	0	1	1	0	0	0	0	0
9/6/2016	8	8	740	880	1	3	26	7	0	0	0	0	0	7
9/7/2016	12N	15	740	850	1	3	8	0	3	0	0	3	0	0
9/8/2016	12N	15	741	950	1	3	1	3	0	3	0	0	0	0
9/8/2016	8	8	742	530	1	2	0	1	0	1	0	0	0	0
9/13/2016	8	8	734	870	1	3	0	2	0	2	0	0	0	0
9/14/2016	8	8	744	705	1	2	23	1	0	1	0	0	0	0
9/14/2016	12N	15	743	790	1	3	3	5	0	5	0	1	0	0
9/16/2016	8	8	745	750	1	2	10	1	0	1	0	0	0	0
9/26/2016	8	8	747	750	1	2	8	3	0	3	0	0	0	0
9/29/2016	8	8	731	1010	1	3	7	3	0	0	2	0	0	0
10/4/2016	20	13	747	600	1	2	0	55	0	20	15	20	0	0
10/5/2016	12N	15	748	940	1	3	28	12	0	12	0	0	0	0
10/11/2016	12N	15	741	845	1	3	25	20	0	18	2	0	0	0
10/11/2016	20	13	751	1195	1	3	19	12	0	7	3	0	0	2
10/11/2016	12N	15	749	350	1	1	12	9	0	4	2	2	1	0
10/11/2016	8	8	747	560	1	2	8	3	0	1	2	0	0	0
10/11/2016	8	8	750	990	1	3	2	2	0	0	2	0	0	0
10/12/2016	20	13	747	640	1	2	19	2	0	2	0	1	0	0
10/12/2016	12N	15	753	915	1	3	17	10	0	9	0	0	0	1
10/12/2016	20	13	747	660	1	2	12	18	0	8	8	2	0	0
10/12/2016	8	8	752	995	1	3	4	18	0	12	6	0	0	0
10/21/2016	12N	15	755	850	1	3	28	8	0	8	0	0	0	0
10/21/2016	20	13	757	1050	1	3	7	5	0	5	0	0	0	0

APPENDIX 4: The measurements of sporulated oocysts and sporocysts from fecal floats in pellet samples from cottontails in New York 2015-2017.

ET	OL	OW	OLW	WALL	WT	C	MW	OR	SL	SW	SR	N	SB	SBW	SSB	SR	SRB	NSRB
627	27.10	15.80	1.72	2.00	1.10	1.00	3.80	3.40	12.50	6.90	1.81	NA	1.00	1.70	NA	2.60	3.80	2.00
627	27.50	15.70	1.75	2.00	1.00	1.00	NA	na	12.20	6.50	1.88	NA	1.00	1.10	0.00	NA	NA	NA
627	26.40	17.50	1.51	2.00	0.80	NA	NA	na	10.50	6.60	1.59	NA	NA	na	na	NA	NA	NA
627	26.70	18.10	1.48	2.00	1.30	1.00	4.50	5.70	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
627	25.70	15.20	1.69	2.00	1.10	1.00	3.20	3.30	11.70	6.50	1.80	NA	1.00	1.50	0.00	2.50	4.20	2.00
627	26.90	15.90	1.69	2.00	1.10	1.00	4.40	na	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
627	25.30	15.80	1.60	2.00	1.20	1.00	3.60	na	12.20	6.40	1.91	NA	1.00	1.70	NA	NA	3.70	2.00
627	27.20	17.50	1.55	2.00	0.90	1.00	4.30	4.35	11.40	6.60	1.73	NA	1.00	4.00	NA	3.10	3.80	2.00
627	25.10	16.00	1.57	2.00	1.00	1.00	4.40	na	13.00	6.90	1.88	NA	1.00	1.50	NA	NA	4.50	2.00
627	25.50	16.40	1.55	2.00	0.70	NA	NA	4.70	11.80	6.30	1.87	NA	1.00	1.20	0.00	3.20	3.30	2.00
654	26.10	13.50	1.93	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
654	29.60	14.70	2.01	NA	NA	1.00	3.60	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
654	29.60	14.60	2.03	NA	NA	1.00	3.70	NA	13.30	6.30	2.11	NA	NA	NA	NA	NA	NA	NA
658	30.00	16.70	1.80	NA	NA	1.00	3.40	NA	14.70	6.50	2.26	NA	NA	NA	NA	NA	3.90	NA
658	33.90	20.80	1.63	1.00	1.20	1.00	4.30	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
658	35.10	19.00	1.85	1.00	1.00	1.00	3.70	NA	16.80	8.60	1.95	NA	NA	NA	NA	NA	NA	NA
658	38.40	19.50	1.97	NA	NA	1.00	3.80	1.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
658	37.30	19.40	1.92	1.00	1.10	1.00	5.00	NA	13.00	8.80	1.48	NA	NA	NA	NA	NA	NA	NA

658	48.20	27.00	1.79	1.00	1.00	1.00	4.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
699	23.90	15.30	1.56	NA	NA	1.00	3.40	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
699	25.20	16.40	1.54	NA	NA	1.00	3.30	NA	11.40	5.40	2.11	NA	NA	NA	NA	NA	3.50	2.00
699	26.80	15.40	1.74	1.00	1.10	1.00	3.50	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
699	27.00	15.50	1.74	1.00	1.10	1.00	4.00	NA	15.50	12.70	1.22	NA	NA	1.50	NA	NA	5.10	2.00
699	27.30	17.70	1.54	NA	NA	NA	NA	NA	8.80	8.70	1.01	NA	NA	NA	NA	NA	NA	NA
699	27.50	15.10	1.82	NA	NA	1.00	3.60	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
699	29.40	17.10	1.72	NA	NA	1.00	3.50	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
699	29.60	17.60	1.68	NA	NA	1.00	4.40	NA	10.20	7.00	1.46	NA	NA	NA	NA	NA	NA	NA
699	32.00	16.60	1.93	NA	NA	NA	NA	NA	15.40	7.20	2.14	NA	NA	NA	NA	NA	NA	NA
699	35.40	18.90	1.87	NA	NA	1.00	5.20	NA	16.80	7.90	2.13	NA	NA	NA	NA	NA	NA	NA
701	24.10	14.90	1.62	2.00	1.00	1.00	3.60	NA	11.50	7.00	1.64	NA	NA	NA	NA	NA	NA	NA
701	25.70	16.70	1.54	2.00	1.00	1.00	3.90	NA	11.90	7.30	1.63	NA	NA	NA	NA	NA	NA	NA
701	27.30	15.70	1.74	2.00	1.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
701	29.20	17.00	1.72	NA	NA	1.00	3.80	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
701	29.80	16.40	1.82	NA	NA	1.00	4.10	NA	13.70	7.70	1.78	NA	NA	NA	NA	NA	NA	NA
701	34.40	19.40	1.77	NA	NA	1.00	4.40	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
702	30.60	17.80	1.72	NA	NA	1.00	4.20	NA	14.80	7.20	2.06	NA	NA	NA	NA	NA	5.80	2.00
708	11.00	8.00	1.38	1.00	0.80	1.00	1.80	0.00	4.40	2.90	1.52	NA	NA	na	NA	NA	NA	2.00
708	37.50	16.80	2.23	1.00	1.00	1.00	2.90	0.00	12.30	6.90	1.78	NA	NA	na	NA	NA	4.40	2.00
708	38.10	16.30	2.34	1.00	1.00	1.00	3.80	0.00	12.10	6.70	1.81	NA	NA	na	NA	4.20	3.50	2.00

708	38.30	16.00	2.39	1.00	0.90	NA	NA	0.00	11.70	5.90	1.98	NA	NA	na	NA	3.20	3.00	2.00
708	38.50	16.20	2.38	1.00	1.10	1.00	3.40	0.00	13.90	6.80	2.04	NA	0.00	na	0.00	3.10	4.40	2.00
708	38.70	21.70	1.78	1.00	0.70	1.00	5.20	0.00	15.10	8.70	1.74	NA	NA	NA	NA	5.30	4.50	2.00
708	40.20	15.60	2.58	1.00	1.20	1.00	3.20	0.00	NA	NA	#VALUE!	NA	NA	NA	NA	NA	NA	NA
708	23.20	16.90	1.37	2.00	1.10	1.00	4.00	0.00	11.30	7.10	1.59	0.00	1.00	1.50	0.00	NA	4.60	2.00
708	39.10	15.40	2.54	2.00	1.10	1.00	3.60	3.00	14.60	6.50	2.25	0.00	1.00	1.30	1.60	3.40	3.50	2.00
708	39.30	16.40	2.40	2.00	1.10	1.00	2.90	3.00	13.60	6.20	2.19	0.00	NA	NA	0.00	2.90	3.60	2.00
708	40.10	16.30	2.46	2.00	0.90	1.00	3.60	3.40	16.10	6.80	2.37	0.00	0.00	NA	1.30	NA	3.40	2.00
708	40.80	22.00	1.85	2.00	1.10	1.00	3.60	4.40	17.90	8.50	2.11	NA	1.00	1.60	NA	3.60	3.80	2.00
708	41.00	20.60	1.99	2.00	1.60	1.00	5.00	3.80	18.30	8.90	2.06	NA	NA	na	NA	NA	4.80	2.00
708	37.40	16.00	2.34	2.00	1.00	1.00	3.50	3.90	17.20	8.60	2.00	NA	1.00	1.30	NA	3.50	3.70	1.00
708	39.30	15.80	2.49	2.00	1.00	1.00	3.80	3.50	15.00	6.30	2.38	NA	1.00	1.40	NA	3.40	4.40	1.00
708	39.00	15.90	2.45	2.00	1.00	1.00	3.50	3.50	15.30	7.00	2.19	NA	1.00	1.50	NA	3.00	4.70	2.00
708	39.80	15.70	2.54	2.00	1.00	1.00	3.50	3.40	16.10	7.00	2.30	NA	1.00	1.30	NA	3.10	3.50	2.00
708	37.90	15.50	2.45	2.00	0.90	1.00	3.40	3.70	14.80	7.30	2.03	0.00	1.00	1.40	0.00	2.90	NA	NA
708	38.20	22.60	1.69	2.00	1.60	1.00	3.80	4.90	15.00	8.40	1.79	NA	NA	NA	NA	NA	3.50	2.00
708	38.40	16.70	2.30	2.00	1.10	1.00	2.60	3.40	15.30	7.40	2.07	0.00	1.00	1.30	0.00	2.50	3.00	2.00
708	28.30	17.60	1.61	2.00	1.40	1.00	3.20	0.00	13.60	6.70	2.03	1.00	1.00	1.40	0.00	2.50	5.40	2.00
708	39.19	17.41	2.29	2.00	1.12	1.00	3.57	3.66	15.77	7.41	2.14	0.00	0.89	1.39	0.58	3.14	3.81	1.82
708	24.20	15.40	1.57	2.00	1.40	1.00	4.00	0.00	10.50	6.90	1.52	NA	NA	NA	0.00	2.70	3.60	2.00
708	23.10	15.30	1.51	2.00	1.10	1.00	4.20	0.00	12.30	6.40	1.92	1.00	1.00	1.20	0.00	2.30	5.00	2.00

708	20.00	14.20	1.41	2.00	1.40	1.00	3.70	0.00	11.90	6.30	1.89	NA	NA	na	0.00	3.00	4.90	2.00
708	22.70	14.90	1.52	2.00	1.00	1.00	4.40	0.00	13.20	6.00	2.20	NA	1.00	1.80	0.00	2.70	4.10	2.00
708	22.00	15.30	1.44	2.00	1.20	1.00	4.50	0.00	12.30	6.70	1.84	NA	1.00	1.60	0.00	2.60	4.60	2.00
708	24.00	15.30	1.57	2.00	1.10	1.00	4.30	0.00	11.40	6.40	1.78	NA	NA	na	0.00	3.60	5.00	2.00
708	21.30	15.30	1.39	2.00	1.20	1.00	4.20	0.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
708	26.00	17.00	1.53	2.00	1.10	1.00	3.00	0.00	8.90	7.40	1.20	1.00	NA	na	NA	3.10	4.20	2.00
708	26.20	17.80	1.47	2.00	1.20	1.00	3.00	0.00	12.10	6.20	1.95	0.00	1.00	1.10	0.00	3.00	4.50	2.00
708	22.40	15.02	1.49	2.00	1.22	1.00	4.16	0.00	12.04	6.46	1.87	1.00	1.00	1.53	0.00	2.66	4.44	2.00
708	19.00	15.90	1.19	2.00	1.00	0.00	NA	0.00	6.60	6.50	1.02	NA	NA	NA	NA	NA	NA	NA
709	27.80	13.70	2.03	NA	NA	1.00	3.30	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
711	28.00	16.50	1.70	1.00	1.10	1.00	4.50	4.40	13.20	6.30	2.10	1.00	1.00	1.40	NA	NA	4.20	2.00
714	24.10	12.90	1.87	NA	NA	1.00	2.90	0.00	13.60	6.40	2.13	0.00	1.00	1.50	0.00	3.10	4.40	2.00
714	26.00	13.40	1.94	1.00	1.00	1.00	3.30	0.00	10.90	6.10	1.79	NA	NA	NA	NA	NA	NA	NA
714	27.20	15.00	1.81	1.00	0.80	1.00	4.20	0.00	13.70	6.70	2.04	0.00	NA	NA	NA	NA	4.30	2.00
714	27.40	16.40	1.67	1.00	1.00	1.00	3.50	0.00	13.70	7.40	1.85	1.00	0.00	na	0.00	0.00	4.60	2.00
714	28.10	14.40	1.95	1.00	0.80	1.00	4.00	0.00	9.90	5.90	1.68	1.00	0.00	NA	0.00	0.00	3.50	2.00
714	28.20	16.50	1.71	1.00	0.90	1.00	3.50	0.00	11.70	5.00	2.34	0.00	NA	na	NA	NA	NA	NA
714	30.20	14.20	2.13	1.00	0.80	1.00	3.60	0.00	11.50	5.60	2.05	0.00	0.00	NA	0.00	0.00	4.00	3.00
714	27.31	14.69	1.87	1.00	0.88	1.00	3.57	0.00	12.14	6.16	1.98	0.33	0.25	1.50	0.00	0.78	4.16	2.20
714	27.20	15.20	1.79	1.00	1.10	1.00	4.60	0.00	15.10	7.50	2.01	1.00	1.00	1.20	0.00	0.00	4.70	2.00
715	22.80	15.10	1.51	1.00	1.10	1.00	3.30	0.00	10.20	5.50	1.85	0.00	NA	NA	NA	NA	NA	NA

715	23.10	14.70	1.57	1.00	1.20	1.00	3.80	0.00	11.40	4.90	2.33	0.00	0.00	na	0.00	0.00	3.60	2.00
715	23.60	15.50	1.52	1.00	0.80	1.00	3.20	0.00	12.00	5.70	2.11	0.00	0.00	na	0.00	0.00	3.90	2.00
715	24.60	15.80	1.56	1.00	0.90	1.00	3.90	0.00	13.00	6.70	1.94	0.00	1.00	1.20	0.00	0.00	3.50	2.00
715	25.10	23.10	1.09	1.00	1.40	1.00	1.40	0.00	15.50	7.80	1.99	0.00	0.00	na	0.00	0.00	4.60	2.00
715	25.60	15.20	1.68	1.00	0.90	1.00	3.20	0.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
715	24.13	16.57	1.49	1.00	1.05	1.00	3.13	0.00	12.42	6.12	2.04	0.00	0.25	1.20	0.00	0.00	3.90	2.00
715	26.20	15.60	1.68	1.00	0.80	0.00	NA	0.00	11.60	6.50	1.78	0.00	0.00	NA	0.00	0.00	3.20	2.00
715	45.80	23.40	1.96	1.00	1.90	1.00	3.00	4.30	19.20	8.20	2.34	0.00	0.00	na	0.00	2.90	4.40	2.00
715	43.80	16.00	2.74	1.00	1.00	1.00	3.60	0.00	20.80	7.60	2.74	0.00	0.00	NA	0.00	2.30	3.50	2.00
715	45.50	16.10	2.83	1.00	0.80	1.00	3.50	0.00	19.50	8.50	2.29	0.00	0.00	NA	0.00	0.00	4.40	2.00
715	45.03	18.50	2.51	1.00	1.23	1.00	3.37	1.43	19.83	8.10	2.46	0.00	0.00	NA	0.00	1.73	4.10	2.00
716	23.20	14.70	1.58	1.00	1.00	1.00	3.70	0.00	12.20	5.90	2.07	0.00	1.00	1.40	0.00	0.00	3.00	2.00
718	45.90	22.90	2.00	1.00	1.60	1.00	4.70	0.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
720	26.80	15.60	1.72	1.00	0.50	1.00	3.60	0.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
720	29.70	16.90	1.76	1.00	0.80	1.00	3.60	0.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
720	28.00	14.80	1.89	1.00	1.00	1.00	4.00	0.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
720	29.60	16.00	1.85	2.00	1.20	1.00	4.50	0.00	12.50	6.30	1.98	1.00	1.00	1.50	0.00	SM GRAN	4.10	2.00
720	29.60	17.40	1.70	2.00	NA	1.00	4.00	0.00	12.40	7.30	1.70	1.00	0.00	NA	0.00	SM GRAN	4.20	2.00
720	32.70	14.40	2.27	2.00	1.20	1.00	4.00	0.00	14.20	7.60	1.87	2.00	NA	NA	0.00	SM GRAN	4.80	2.00
720	25.40	13.90	1.83	2.00	1.10	1.00	3.00	3.20	10.50	6.60	1.59	0.00	1.00	1.50	0.00	SM GRAN	3.90	2.00
720	30.30	16.10	1.88	2.00	1.30	1.00	4.00	0.00	12.10	6.50	1.86	1.00	0.00	NA	0.00	SM GRAN	4.00	2.00

720	29.52	15.56	1.91	2.00	1.20	1.00	3.90	0.00	12.34	6.86	1.80	1.00	0.50	1.50	0.00	#DIV/0!	4.20	2.00
720	29.80	18.60	1.60	1.00	0.80	1.00	3.60	0.00	12.00	6.20	1.94	0.00	0.00	NA	0.00	0.00	0.00	NA
723	24.50	14.20	1.73	1.00	1.10	1.00	3.00	0.00	13.00	6.00	2.17	2.00	1.00	1.10	0.00	0.00	4.40	2.00
723	25.40	14.00	1.81	1.00	0.80	1.00	3.10	0.00	NA	NA	#VALUE!	NA	NA	NA	NA	NA	NA	NA
723	24.95	14.10	1.77	1.00	0.95	1.00	3.05	0.00	13.00	6.00	2.17	2.00	1.00	1.10	0.00	0.00	4.40	2.00
725	30.30	14.90	2.03	1.00	0.80	1.00	4.30	0.00	13.70	6.70	2.04	0.00	1.00	1.30	0.00	0.00	4.60	2.00
725	30.40	14.10	2.16	1.00	0.90	1.00	4.20	0.00	14.20	5.80	2.45	0.00	0.00	NA	0.00	0.00	4.20	2.00
725	28.60	14.00	2.04	1.00	0.80	1.00	3.80	0.00	14.20	5.80	2.45	0.00	1.00	1.20	0.00	0.00	4.70	2.00
725	28.60	15.70	1.82	1.00	1.00	1.00	3.90	0.00	14.40	6.00	2.40	0.00	0.00	NA	0.00	0.00	4.30	2.00
725	29.10	14.80	1.97	1.00	0.80	1.00	3.90	0.00	12.80	5.80	2.21	1.00	0.00	NA	0.00	0.00	3.30	2.00
725	29.30	14.90	1.97	1.00	0.90	1.00	4.00	0.00	14.30	6.80	2.10	0.00	0.00	NA	0.00	0.00	4.70	2.00
725	29.00	14.40	2.01	1.00	1.10	1.00	3.70	0.00	13.40	5.70	2.35	1.00	0.00	NA	0.00	0.00	3.40	2.00
725	29.50	13.90	2.12	1.00	1.00	1.00	3.80	0.00	12.00	5.10	2.35	1.00	0.00	NA	1.80	0.00	4.00	2.00
725	28.30	16.10	1.76	1.00	0.90	1.00	3.80	0.00	14.40	6.10	2.36	1.00	0.00	NA	0.00	0.00	4.70	2.00
725	28.70	15.90	1.81	1.00	1.10	1.00	3.90	0.00	14.80	6.70	2.21	1.00	1.00	1.80	0.00	0.00	3.80	2.00
725	27.30	15.60	1.75	1.00	0.90	1.00	3.60	0.00	11.50	6.40	1.80	1.00	0.00	NA	0.00	4.40	3.60	1.00
725	27.90	14.50	1.92	1.00	1.10	1.00	3.50	0.00	13.80	6.70	2.06	1.00	1.00	2.10	0.00	0.00	3.60	2.00
725	27.50	14.00	1.96	1.00	0.80	1.00	NA	0.00	13.60	5.50	2.47	2.00	0.00	NA	0.00	0.00	3.60	2.00
725	27.90	15.70	1.78	1.00	0.90	1.00	4.70	0.00	15.10	6.40	2.36	0.00	0.00	NA	0.00	0.00	5.30	2.00
725	30.30	15.40	1.97	1.00	0.80	1.00	4.10	0.00	14.00	6.30	2.22	0.00	0.00	NA	0.00	0.00	3.40	2.00
725	28.10	15.80	1.78	1.00	0.80	1.00	4.10	0.00	13.50	6.60	2.05	2.00	0.00	NA	0.00	3.30	4.60	2.00

725	28.60	16.70	1.71	1.00	1.10	1.00	3.50	0.00	15.00	7.00	2.14	1.00	1.00	1.60	0.00	0.00	5.00	2.00
725	31.90	16.00	1.99	1.00	0.80	1.00	4.30	0.00	14.70	7.00	2.10	0.00	0.00	NA	0.00	0.00	5.20	2.00
725	29.10	13.90	2.09	1.00	0.80	1.00	3.40	0.00	13.40	6.10	2.20	0.00	0.00	NA	0.00	3.10	3.50	2.00
725	30.50	13.60	2.24	1.00	1.30	1.00	2.10	0.00	13.80	6.60	2.09	2.00	1.00	1.70	0.00	0.00	3.40	2.00
725	29.40	13.50	2.18	1.00	0.70	1.00	3.50	0.00	13.70	6.50	2.11	3.00	1.00	1.90	0.00	0.00	3.40	2.00
725	27.30	14.60	1.87	1.00	0.80	1.00	3.90	0.00	13.10	6.20	2.11	1.00	0.00	0.00	0.00	0.00	3.50	2.00
725	27.40	15.60	1.76	NA	NA	1.00	3.80	0.00	14.80	6.30	2.35	1.00	1.00	1.30	0.00	0.00	4.10	2.00
725	28.10	15.20	1.85	NA	NA	1.00	4.40	0.00	14.10	6.00	2.35	0.00	0.00	NA	0.00	0.00	5.00	2.00
725	26.50	15.60	1.70	1.00	1.10	1.00	4.40	0.00	15.20	6.40	2.38	0.00	0.00	NA	0.00	0.00	3.60	2.00
725	28.50	15.10	1.89	1.00	1.00	1.00	3.70	0.00	15.00	6.30	2.38	0.00	1.00	1.60	0.00	0.00	5.10	2.00
725	28.20	14.80	1.91	1.00	1.00	1.00	3.80	0.00	15.20	6.50	2.34	1.00	1.00	1.80	0.00	0.00	3.90	2.00
725	28.50	14.60	1.95	1.00	0.90	1.00	3.40	0.00	11.20	6.70	1.67	0.00	0.00	NA	0.00	0.00	3.10	2.00
725	27.20	14.10	1.93	1.00	0.70	1.00	3.70	0.00	13.70	7.00	1.96	2.00	0.00	NA	0.00	2.40	3.40	2.00
725	28.90	15.70	1.84	1.00	0.90	1.00	4.10	0.00	13.90	5.60	2.48	0.00	0.00	NA	0.00	0.00	4.30	2.00
725	27.10	14.90	1.82	1.00	1.00	1.00	4.20	0.00	14.00	6.80	2.06	0.00	0.00	NA	0.00	0.00	4.30	2.00
725	27.60	16.70	1.65	1.00	0.80	1.00	2.90	0.00	16.10	6.50	2.48	1.00	1.00	2.00	0.00	0.00	4.00	2.00
725	28.90	15.70	1.84	1.00	1.10	1.00	3.40	0.00	11.30	5.10	2.22	NA	NA	NA	NA	NA	NA	NA
725	29.10	15.80	1.84	1.00	1.00	1.00	3.70	0.00	15.30	6.70	2.28	2.00	1.00	1.70	0.00	0.00	5.10	2.00
725	27.50	14.80	1.86	1.00	0.70	1.00	3.20	0.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
725	30.40	14.60	2.08	1.00	1.00	1.00	NA	0.00	14.70	6.10	2.41	1.00	1.00	1.30	0.00	0.00	4.80	2.00
725	28.40	16.10	1.76	1.00	1.00	1.00	4.00	0.00	14.40	6.60	2.18	0.00	1.00	1.70	0.00	0.00	4.40	2.00

725	28.65	15.06	1.91	1.00	0.92	1.00	3.79	0.00	13.95	6.29	2.23	0.74	0.40	1.53	0.05	0.38	4.14	1.97
725	22.90	17.40	1.32	1.00	1.10	1.00	4.90	0.00	14.60	5.90	2.47	0.00	0.00	NA	0.00	0.00	3.50	1.00
725	22.10	15.00	1.47	1.00	0.80	1.00	3.80	0.00	13.60	6.60	2.06	0.00	0.00	NA	0.00	0.00	3.30	2.00
725	22.40	15.40	1.45	1.00	0.70	1.00	4.10	0.00	13.30	5.80	2.29	0.00	0.00	NA	0.00	0.00	3.20	2.00
725	22.25	15.20	1.46	1.00	0.75	1.00	3.95	0.00	13.45	6.20	2.18	0.00	0.00	#DIV/0!	0.00	0.00	3.25	2.00
725	25.10	14.40	1.74	1.00	0.90	1.00	4.00	0.00	14.50	6.30	2.30	1.00	0.00	NA	0.00	0.00	4.00	2.00
725	26.60	13.80	1.93	1.00	0.90	1.00	3.70	0.00	13.20	5.80	2.28	1.00	0.00	NA	0.00	0.00	4.70	2.00
725	27.80	14.50	1.92	1.00	0.70	1.00	3.50	0.00	14.00	6.40	2.19	1.00	0.00	NA	0.00	0.00	4.20	2.00
725	27.10	14.40	1.88	1.00	0.70	1.00	3.60	0.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
725	25.20	15.30	1.65	1.00	1.10	1.00	4.00	0.00	12.30	5.90	2.08	0.00	0.00	NA	0.00	0.00	3.70	NA
725	26.60	15.10	1.76	1.00	0.80	1.00	4.10	0.00	13.40	5.80	2.31	0.00	0.00	NA	1.50	0.00	5.00	2.00
725	23.10	15.80	1.46	NA	NA	1.00	4.40	NA	NA	NA	#VALUE!	NA	NA	NA	NA	NA	NA	NA
725	24.90	16.00	1.56	1.00	1.00	1.00	4.30	0.00	14.30	6.20	2.31	1.00	0.00	NA	0.00	0.00	3.60	2.00
725	25.80	14.90	1.73	1.00	1.00	1.00	3.00	0.00	NA	NA	#DIV/0!	NA	NA	NA	NA	NA	NA	NA
725	24.70	14.40	1.72	1.00	0.80	1.00	3.90	0.00	14.20	6.40	2.22	2.00	1.00	1.50	0.00	0.00	3.20	NA
725	26.30	14.40	1.83	1.00	0.70	1.00	3.20	0.00	14.10	6.60	2.14	NA	NA	NA	NA	NA	3.70	2.00
725	26.10	14.70	1.78	1.00	1.10	1.00	3.50	0.00	NA	NA	NA	0.00	0.00	NA	0.00	0.00	3.70	NA
725	34.30	16.30	2.10	1.00	0.90	1.00	NA	2.70	13.90	6.40	2.17	0.00	0.00	NA	0.00	4.50	3.70	2.00
725	37.70	16.30	2.31	1.00	1.10	1.00	3.50	0.00	13.50	6.70	2.01	0.00	0.00	NA	0.00	0.00	3.30	2.00
725	38.50	16.20	2.38	NA	NA	1.00	4.00	0.00	14.40	7.00	2.06	0.00	0.00	NA	0.00	5.40	5.10	5.00
725	36.90	16.60	2.22	1.00	1.10	1.00	4.80	0.00	15.00	6.60	2.27	1.00	0.00	NA	0.00	5.80	NA	4.50

725	37.70	16.37	2.30	1.00	1.10	1.00	4.10	0.00	14.30	6.77	2.11	0.33	0.00	#DIV/0!	0.00	3.73	4.20	3.83
725	24.10	12.90	1.87	1.00	0.60	1.00	4.00	0.00	7.30	6.80	1.07	0.00	0.00	NA	0.00	0.00	2.50	4.00
726	25.10	14.10	1.78	1.00	0.80	1.00	3.60	0.00	10.50	6.50	1.62	0.00	0.00	NA	0.00	0.00	3.70	2.00
726	25.50	16.00	1.59	1.00	0.80	1.00	3.90	0.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
726	27.20	17.30	1.57	1.00	1.20	1.00	3.40	0.00	14.10	6.30	2.24	2.00	0.00	NA	0.00	0.00	5.00	2.00
726	27.20	17.00	1.60	1.00	1.10	1.00	3.60	0.00	12.30	5.70	2.16	2.00	0.00	NA	0.00	0.00	4.60	2.00
726	29.00	17.90	1.62	1.00	1.00	1.00	4.30	0.00	15.50	6.90	2.25	0.00	1.00	1.80	0.00	0.00	5.80	2.00
726	26.80	16.46	1.63	1.00	0.98	1.00	3.76	0.00	13.10	6.35	2.06	1.00	0.25	1.80	0.00	0.00	4.78	2.00
726	23.80	15.60	1.53	1.00	0.90	1.00	4.00	0.00	14.50	6.20	2.34	1.00	0.00	NA	0.00	0.00	4.50	2.00
726	20.60	14.60	1.41	1.00	0.80	1.00	4.80	0.00	11.30	6.10	1.85	0.00	0.00	NA	0.00	0.00	3.90	2.00
726	23.90	16.20	1.48	NA	NA	0.00	NA	0.00	14.40	6.90	2.09	0.00	0.00	NA	0.00	0.00	5.10	2.00
726	22.77	15.47	1.47	1.00	0.85	0.67	4.40	0.00	13.40	6.40	2.09	0.33	0.00	#DIV/0!	0.00	0.00	4.50	2.00
729	25.10	16.40	1.53	1.00	1.00	0.00	NA	0.00	12.60	6.50	1.94	0.00	0.00	NA	0.00	0.00	4.90	2.00
729	25.90	15.30	1.69	1.00	0.90	1.00	3.30	0.00	12.20	5.90	2.07	1.00	1.00	1.60	0.00	0.00	2.80	2.00
729	26.00	14.40	1.81	1.00	1.00	1.00	4.20	0.00	13.50	6.00	2.25	1.00	0.00	NA	0.00	2.80	4.30	2.00
729	27.10	15.80	1.72	1.00	0.90	1.00	4.60	0.00	11.10	7.20	1.54	NA	NA	NA	NA	NA	NA	NA
729	27.60	15.40	1.79	1.00	0.80	1.00	3.20	0.00	NA	NA	#DIV/0!	NA	NA	NA	NA	NA	NA	NA
729	27.80	15.90	1.75	1.00	0.80	1.00	3.60	0.00	13.60	6.30	2.16	0.00	0.00	NA	0.00	3.00	4.80	2.00
729	28.10	15.60	1.80	1.00	1.00	1.00	3.50	0.00	12.10	7.30	1.66	0.00	0.00	NA	NA	0.00	4.60	2.00
729	28.40	16.20	1.75	1.00	1.10	1.00	3.90	0.00	12.70	5.90	2.15	NA	1.00	1.50	NA	0.00	5.20	2.00
729	26.90	15.60	1.72	1.00	1.10	1.00	3.30	0.00	11.50	6.20	1.85	2.00	0.00	NA	0.00	0.00	4.70	2.00

729	29.10	13.90	2.09	1.00	0.90	1.00	3.60	0.00	12.80	6.20	2.06	NA	1.00	1.50	0.00	3.30	4.60	4.00
729	29.20	14.70	1.99	1.00	0.90	1.00	4.40	0.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
729	29.20	15.00	1.95	1.00	1.10	1.00	4.30	0.00	13.80	6.10	2.26	1.00	NA	NA	NA	NA	3.70	2.00
729	29.50	14.90	1.98	1.00	1.00	1.00	3.80	0.00	11.30	7.30	1.55	1.00	0.00	NA	NA	1.00	3.50	2.00
729	30.00	16.00	1.88	1.00	1.00	1.00	3.80	0.00	11.80	7.10	1.66	NA	NA	NA	NA	NA	NA	NA
729	30.10	14.50	2.08	1.00	0.70	1.00	3.50	0.00	12.20	6.50	1.88	NA	NA	NA	NA	NA	NA	NA
729	24.20	15.60	1.55	1.00	1.00	1.00	4.50	0.00	12.80	5.70	2.25	0.00	0.00	NA	NA	NA	4.40	2.00
731	29.50	15.40	1.92	1.00	1.20	1.00	4.00	0.00	13.20	7.00	1.89	0.00	0.00	NA	0.00	2.60	4.50	2.00
731	29.10	16.20	1.80	1.00	1.00	1.00	3.90	0.00	13.30	7.10	1.87	1.20	0.00	NA	0.00	2.80	4.40	2.00
731	28.50	14.90	1.91	1.00	1.00	1.00	3.90	0.00	12.80	6.90	1.86	0.00	0.00	NA	0.00	2.60	5.30	2.00
731	27.80	15.50	1.79	1.00	0.90	1.00	4.00	0.00	12.40	6.30	1.97	0.00	0.00	NA	0.00	3.30	4.20	2.00
731	28.73	15.50	1.85	1.00	1.03	1.00	3.95	0.00	12.93	6.83	1.90	0.30	0.00	#DIV/0!	0.00	2.83	4.60	2.00
731	27.90	15.20	1.84	1.00	0.90	1.00	3.90	0.00	12.60	6.90	1.83	0.00	0.00	NA	0.00	0.00	5.10	2.00
731	28.00	14.50	1.93	1.00	0.90	1.00	3.80	0.00	12.80	6.50	1.97	0.00	1.00	1.50	0.00	0.00	4.00	2.00
731	27.80	16.20	1.72	1.00	1.00	1.00	4.70	0.00	14.10	7.50	1.88	0.00	0.00	NA	0.00	0.00	5.20	2.00
731	27.20	15.20	1.79	1.00	1.00	1.00	3.60	0.00	12.70	6.60	1.92	0.00	0.00	NA	0.00	0.00	5.70	2.00
731	28.90	15.20	1.90	1.00	1.00	1.00	4.60	0.00	13.70	6.30	2.17	0.00	0.00	NA	0.00	0.00	4.40	2.00
731	29.30	15.30	1.92	1.00	1.00	1.00	3.40	0.00	12.70	6.20	2.05	0.00	0.00	NA	0.00	0.00	5.50	2.00
731	30.70	16.40	1.87	1.00	0.90	1.00	3.80	0.00	13.10	7.00	1.87	1.00	0.00	NA	1.70	0.00	4.70	2.00
731	30.80	16.30	1.89	1.00	0.90	1.00	4.20	0.00	14.80	7.20	2.06	0.00	1.00	1.80	0.00	0.00	0.00	NA
731	30.80	15.30	2.01	1.00	0.90	1.00	4.10	0.00	13.20	6.80	1.94	0.00	0.00	NA	0.00	0.00	5.60	2.00

731	29.04	15.51	1.87	1.00	0.94	1.00	4.01	0.00	13.30	6.78	1.97	0.11	0.22	1.65	0.19	0.00	4.47	2.00
731	25.40	14.30	1.78	1.00	0.90	1.00	4.10	0.00	12.70	6.40	1.98	0.00	0.00	NA	0.00	0.00	5.00	2.00
731	25.50	15.90	1.60	1.00	1.00	1.00	3.40	0.00	11.90	6.60	1.80	0.00	0.00	NA	0.00	1.80	4.30	2.00
731	26.00	15.70	1.66	1.00	1.10	1.00	3.80	0.00	11.80	7.20	1.64	0.00	0.00	NA	0.00	0.00	5.40	2.00
731	26.10	16.10	1.62	1.00	9.00	0.00	NA	0.00	13.90	6.40	2.17	0.00	0.00	NA	0.00	2.70	4.90	2.00
731	26.70	13.70	1.95	1.00	1.10	1.00	4.10	0.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
731	27.50	15.40	1.79	1.00	0.90	1.00	4.70	0.00	14.50	7.10	2.04	0.00	0.00	NA	0.00	0.00	5.50	2.00
731	26.20	15.18	1.73	1.00	2.33	0.83	4.02	0.00	12.96	6.74	1.93	0.00	0.00	#DIV/0!	0.00	0.90	5.02	2.00
737	20.40	14.50	1.41	2.00	0.90	0.00	NA	0.00	8.80	5.70	1.54	1.00	0.00	NA	0.00	0.00	3.70	2.00
737	28.50	16.60	1.72	1.00	1.00	1.00	3.90	4.40	12.90	7.30	1.77	1.00	0.00	NA	1.90	5.00	4.50	2.00
737	29.80	17.10	1.74	1.00	1.00	1.00	3.00	4.10	13.10	7.30	1.79	0.00	0.00	NA	0.00	2.40	5.00	2.00
737	23.70	14.00	1.69	1.00	0.90	1.00	3.70	0.00	10.10	5.40	1.87	0.00	NA	NA	NA	NA	3.60	2.00
737	27.33	15.90	1.72	1.00	0.97	1.00	3.53	2.83	12.03	6.67	1.81	0.33	0.00	#DIV/0!	0.95	3.70	4.37	2.00
737	29.30	17.40	1.68	1.00	1.00	1.00	4.20	0.00	14.70	7.90	1.86	0.00	1.00	1.50	0.00	3.40	5.90	2.00
737	30.30	17.00	1.78	1.00	1.10	1.00	3.10	0.00	15.30	7.00	2.19	0.00	1.00	1.70	0.00	4.80	5.00	2.00
737	31.10	17.30	1.80	1.00	0.80	1.00	4.60	0.00	13.10	6.50	2.02	0.00	0.00	NA	0.00	3.60	4.10	2.00
737	31.20	17.10	1.82	1.00	1.00	1.00	4.30	0.00	15.60	7.00	2.23	0.00	1.00	1.30	0.00	0.00	5.30	2.00
737	31.20	16.20	1.93	1.00	1.10	1.00	4.10	0.00	16.60	7.80	2.13	0.00	1.00	2.00	0.00	0.00	6.20	2.00
737	31.70	16.60	1.91	NA	NA	1.00	3.50	0.00	16.80	7.20	2.33	0.00	1.00	1.60	0.00	2.90	5.30	2.00
737	32.20	16.60	1.94	1.00	1.10	1.00	4.00	0.00	15.20	6.60	2.30	0.00	1.00	1.60	0.00	0.00	5.40	2.00
737	32.20	15.70	2.05	1.00	1.10	1.00	4.00	0.00	15.20	6.70	2.27	1.20	1.00	1.40	0.00	2.90	5.20	2.00

737	32.30	16.90	1.91	1.00	0.90	1.00	3.80	0.00	15.90	8.20	1.94	NA	NA	NA	NA	NA	NA	NA
737	32.40	17.80	1.82	1.00	1.00	1.00	3.70	0.00	15.30	7.40	2.07	0.00	2.00	1.60	0.00	0.00	5.40	2.00
737	32.60	16.60	1.96	1.00	1.20	1.00	4.20	0.00	16.20	7.30	2.22	0.00	1.00	1.50	0.00	NA	5.00	2.00
737	32.70	16.40	1.99	1.00	1.00	1.00	4.40	0.00	15.90	7.40	2.15	0.00	1.00	1.30	0.00	0.00	5.30	2.00
737	32.80	16.90	1.94	1.00	1.00	1.00	3.50	0.00	16.60	7.50	2.21	0.00	1.00	2.40	0.00	0.00	5.50	2.00
737	32.80	16.90	1.94	1.00	1.10	1.00	3.70	0.00	16.30	6.50	2.51	0.00	1.00	1.30	0.00	0.00	5.10	2.00
737	33.50	18.50	1.81	1.00	0.90	1.00	4.80	0.00	14.30	7.80	1.83	NA	NA	NA	NA	NA	NA	NA
737	33.50	16.20	2.07	1.00	0.80	1.00	3.80	0.00	15.50	7.40	2.09	0.00	1.00	1.80	0.00	3.90	5.40	2.00
737	33.60	17.40	1.93	1.00	0.90	1.00	3.40	0.00	15.90	7.50	2.12	0.00	1.00	1.70	0.00	2.40	5.60	2.00
737	33.60	16.90	1.99	NA	NA	1.00	3.20	0.00	15.70	7.40	2.12	0.00	1.00	1.50	1.90	0.00	5.40	2.00
737	33.70	17.70	1.90	1.00	1.00	1.00	4.00	0.00	16.40	7.40	2.22	0.00	1.00	1.50	0.00	2.20	4.50	2.00
737	34.00	16.60	2.05	1.00	0.80	1.00	3.80	0.00	15.80	6.60	2.39	0.00	0.00	NA	0.00	0.00	6.00	2.00
737	34.20	15.40	2.22	1.00	1.10	1.00	4.10	0.00	13.40	7.10	1.89	0.00	0.00	NA	0.00	0.00	0.00	NA
737	34.40	16.90	2.04	1.00	0.90	1.00	3.00	0.00	16.70	7.60	2.20	0.00	1.00	1.70	0.00	3.00	6.10	2.00
737	34.50	16.20	2.13	1.00	1.00	1.00	4.10	0.00	15.60	7.50	2.08	1.00	1.00	1.50	0.00	2.90	5.30	2.00
737	34.70	17.40	1.99	1.00	0.80	1.00	3.30	0.00	15.60	7.80	2.00	0.00	1.00	1.50	0.00	2.60	6.40	2.00
737	34.80	16.50	2.11	1.00	1.10	1.00	3.60	0.00	16.60	7.90	2.10	2.00	1.00	1.90	0.00	2.70	4.90	2.00
737	34.90	18.00	1.94	1.00	1.10	1.00	3.20	0.00	15.70	7.80	2.01	0.00	1.00	2.00	0.00	3.80	5.00	2.00
737	34.90	17.50	1.99	1.00	1.00	1.00	3.70	0.00	16.60	7.50	2.21	0.00	1.00	1.30	0.00	2.50	4.60	2.00
737	34.90	17.30	2.02	NA	NA	1.00	3.50	0.00	14.80	6.90	2.14	1.00	1.00	2.10	0.00	3.20	4.60	2.00
737	34.90	16.80	2.08	1.00	0.90	1.00	4.80	0.00	15.90	7.80	2.04	0.00	1.00	1.50	0.00	0.00	5.70	2.00

737	34.90	15.80	2.21	1.00	0.90	1.00	3.70	0.00	16.90	7.70	2.19	1.00	0.00	NA	0.00	0.00	5.70	2.00
737	35.00	17.60	1.99	1.00	0.90	1.00	4.50	0.00	10.20	7.80	1.31	NA	NA	NA	NA	NA	NA	NA
737	35.10	18.20	1.93	1.00	0.90	1.00	3.70	0.00	17.30	8.20	2.11	0.00	1.00	1.50	0.00	0.00	6.00	2.00
737	33.25	16.95	1.96	1.00	0.98	1.00	3.85	0.00	15.55	7.40	2.11	0.21	0.90	1.63	0.07	1.67	5.17	2.00
737	35.10	17.10	2.05	1.00	0.90	1.00	4.00	2.30	15.40	7.80	1.97	0.00	1.00	1.70	0.00	0.00	5.40	2.00
737	35.10	17.00	2.06	1.00	7.00	1.00	3.50	2.30	15.40	7.40	2.08	0.00	1.00	1.30	0.00	0.00	5.50	2.00
737	35.50	16.50	2.15	1.00	0.70	1.00	3.70	2.30	16.10	7.40	2.18	1.00	1.00	1.40	0.00	2.40	5.90	2.00
737	35.50	15.90	2.23	1.00	1.20	1.00	4.20	2.30	15.80	7.30	2.16	0.00	1.00	1.60	0.00	2.90	5.70	2.00
737	35.60	17.20	2.07	1.00	1.00	1.00	3.50	2.40	15.80	7.00	2.26	1.00	0.00	NA	1.10	2.80	5.60	2.00
737	35.70	17.20	2.08	1.00	0.90	1.00	4.20	2.40	16.00	7.20	2.22	1.00	1.00	1.60	0.00	3.20	4.70	2.00
737	35.70	16.50	2.16	1.00	0.80	1.00	3.50	2.50	15.40	7.20	2.14	0.00	1.00	1.50	0.00	2.50	5.60	2.00
737	35.70	16.40	2.18	1.00	1.20	1.00	4.30	2.60	15.00	6.60	2.27	0.00	1.00	1.50	0.00	2.80	4.40	2.00
737	35.80	17.90	2.00	1.00	0.90	1.00	3.70	2.60	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
737	35.80	17.20	2.08	1.00	1.10	1.00	4.10	2.70	15.10	7.50	2.01	0.00	1.00	1.50	0.00	3.10	5.60	2.00
737	35.90	17.70	2.03	1.00	1.20	1.00	4.10	2.70	16.30	7.30	2.23	0.00	1.00	1.00	1.60	2.80	6.30	2.00
737	35.90	16.90	2.12	1.00	1.20	1.00	4.10	2.70	15.60	7.20	2.17	0.00	1.00	1.80	0.00	2.80	5.60	2.00
737	36.30	16.00	2.27	1.00	0.90	1.00	3.90	2.70	15.90	7.10	2.24	0.00	1.00	1.70	0.00	2.90	6.00	2.00
737	36.50	17.90	2.04	1.00	0.90	1.00	3.30	2.80	16.70	7.60	2.20	1.00	0.00	NA	0.00	0.00	5.80	2.00
737	36.50	17.30	2.11	1.00	0.90	1.00	5.40	3.10	16.10	7.50	2.15	0.00	1.00	1.30	0.00	0.00	5.00	2.00
737	36.60	18.50	1.98	1.00	0.90	1.00	3.80	3.10	15.10	7.80	1.94	0.00	1.00	1.50	0.00	2.60	5.10	2.00
737	36.60	17.60	2.08	1.00	1.20	1.00	3.40	3.20	15.10	7.50	2.01	0.00	0.00	NA	0.00	0.00	4.70	1.00

737	37.00	16.90	2.19	1.00	1.10	1.00	4.30	3.20	16.30	7.20	2.26	0.00	1.00	1.60	0.00	2.10	4.80	2.00
737	37.10	17.70	2.10	1.00	1.10	1.00	3.70	3.20	15.90	7.50	2.12	0.00	1.00	2.00	0.00	2.90	5.50	2.00
737	38.30	16.90	2.27	1.00	1.10	0.00	3.30	3.60	15.60	7.60	2.05	0.00	1.00	1.30	0.00	3.30	3.70	2.00
737	21.70	13.90	1.56	1.00	0.80	0.00	NA	0.00	12.20	5.50	2.22	0.00	1.00	1.60	0.00	0.00	3.60	2.00
737	22.80	14.80	1.54	1.00	1.00	0.00	NA	0.00	11.70	6.10	1.92	0.00	0.00	NA	0.00	0.00	3.60	2.00
737	23.70	14.50	1.63	1.00	0.70	0.00	NA	0.00	11.70	5.50	2.13	0.00	0.00	NA	0.00	3.10	4.00	2.00
738	28.60	15.50	1.85	2***	1.50	0.00	na	0.00	13.30	7.70	1.73	NA	NA	NA	NA	NA	NA	NA
739	25.70	13.80	1.86	1.00	0.80	1.00	3.30	0.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
739	25.90	14.70	1.76	1.00	0.80	1.00	3.90	0.00	11.20	5.60	2.00	1.00	0.00	NA	0.00	2.40	4.50	2.00
740	23.50	13.70	1.72	1.00	1.00	1.00	3.30	0.00	12.70	5.60	2.27	0.00	NA	NA	NA	NA	5.60	2.00
740	24.30	14.40	1.69	1.00	1.00	1.00	3.30	0.00	13.00	4.50	2.89	0.00	1.00	1.20	0.00	2.20	4.20	2.00
740	24.40	14.80	1.65	1.00	1.00	1.00	3.50	0.00	13.20	6.30	2.10	0.00	1.00	1.50	0.00	2.20	4.10	2.00
740	26.20	13.40	1.96	1.00	0.80	1.00	3.40	0.00	12.20	5.80	2.10	1.00	1.00	1.50	0.00	NA	4.20	2.00
740	26.30	13.80	1.91	1.00	0.80	1.00	3.00	0.00	13.90	5.70	2.44	0.00	1.00	1.50	2.40	4.90	2.00	NA
740	27.00	14.40	1.88	1.00	0.80	1.00	3.30	0.00	13.70	5.70	2.40	0.00	1.00	1.50	NA	NA	NA	NA
740	27.10	14.60	1.86	1.00	0.90	1.00	2.90	0.00	13.60	6.00	2.27	1.00	1.00	1.40	0.00	2.60	4.90	2.00
740	28.00	15.30	1.83	1.00	0.90	1.00	3.40	0.00	13.90	6.30	2.21	0.00	1.00	1.60	0.00	2.10	4.50	2.00
740	28.20	15.10	1.87	1.00	0.80	1.00	3.80	0.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
740	28.50	15.30	1.86	1.00	1.00	1.00	4.60	0.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
740	28.50	15.10	1.89	1.00	0.90	1.00	4.90	0.00	13.50	5.50	2.45	NA	NA	NA	NA	NA	NA	NA
740	29.00	14.50	2.00	1.00	0.70	1.00	3.80	0.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

740	29.00	14.40	2.01	1.00	1.10	1.00	4.50	0.00	13.00	6.40	2.03	0.00	NA	NA	NA	NA	4.50	2.00
740	29.30	15.70	1.87	1.00	1.10	1.00	4.20	0.00	14.00	6.20	2.26	NA	NA	NA	NA	NA	NA	NA
740	30.30	14.70	2.06	1.00	0.80	NA	NA	0.00	13.10	6.40	2.05	0.00	0.00	NA	0.00	3.30	4.70	2.00
740	30.50	15.40	1.98	1.00	1.00	1.00	3.40	0.00	14.30	5.80	2.47	0.00	NA	NA	NA	NA	5.40	2.00
740	30.90	16.50	1.87	1.00	1.00	1.00	4.10	0.00	14.80	6.30	2.35	0.00	1.00	1.60	NA	3.10	2.50	2.00
740	30.90	14.30	2.16	1.00	1.00	1.00	4.10	0.00	15.00	6.60	2.27	0.00	1.00	2.10	0.00	3.30	5.00	2.00
740	31.40	16.30	1.93	1.00	1.00	1.00	3.70	0.00	15.80	7.00	2.26	0.00	1.00	1.60	0.00	0.00	7.00	2.00
740	31.40	14.80	2.12	1.00	0.80	1.00	4.20	0.00	15.00	6.30	2.38	0.00	1.00	1.70	0.00	2.00	5.50	2.00
740	32.40	15.90	2.04	1.00	1.00	1.00	3.90	0.00	14.50	6.40	2.27	NA	NA	NA	NA	NA	NA	NA
755	23.70	14.70	1.61	1.00	0.80	0.00	NA	0.00	13.90	5.80	2.40	NA	NA	NA	NA	NA	NA	NA
755	24.50	14.20	1.73	1.00	0.90	0.00	NA	0.00	13.30	6.60	2.02	1.00	1.00	1.80	0.00	2.40	4.30	2.00
755	26.30	16.30	1.61	1.00	0.70	0.00	NA	0.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
755	25.30	15.30	1.65	1.00	1.00	NA	NA	0.00	16.00	6.70	2.39	2.00	NA	NA	NA	2.50	4.50	2.00
755	23.60	12.80	1.84	1.00	1.00	na	na	0.00	12.40	5.70	2.18	NA	NA	NA	NA	2.20	3.90	NA
755	24.68	14.66	1.69	1.00	0.88	0.00	#DIV/0!	0.00	13.90	6.20	2.24	1.50	1.00	1.80	0.00	2.37	4.23	2.00
755	22.20	14.30	1.55	1.00	0.80	1.00	3.10	0.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
755	24.60	15.00	1.64	1.00	1.00	1.00	3.70	0.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
755	22.70	14.90	1.52	1.00	1.20	1.00	3.40	0.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
755	24.00	15.30	1.57	1.00	0.70	1.00	NA	0.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
755	24.70	15.30	1.61	1.00	0.90	1.00	3.80	0.00	11.90	5.80	2.05	0.00	1.00	1.50	0.00	2.40	3.80	2.00
755	24.80	15.40	1.61	1.00	0.90	1.00	3.70	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

755	24.20	15.30	1.58	1.00	1.00	1.00	3.70	0.00	11.50	6.20	1.85	1.00	NA	NA	0.00	2.80	3.70	2.00
755	24.30	15.60	1.56	1.00	0.90	1.00	3.90	0.00	NA	NA	#DIV/0!	NA	NA	NA	NA	NA	NA	NA
755	22.60	14.20	1.59	1.00	0.90	1.00	2.90	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
755	24.10	13.80	1.75	NA	NA	1.00	4.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
755	24.10	15.30	1.58	1.00	0.90	1.00	3.60	0.00	12.70	6.40	1.98	NA	1.00	1.50	NA	NA	4.50	2.00
755	22.70	15.50	1.46	1.00	0.80	1.00	3.50	0.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
755	23.90	15.60	1.53	1.00	0.80	1.00	3.40	0.00	13.40	5.90	2.27	NA	1.00	1.50	NA	3.30	NA	NA
755	25.10	15.00	1.67	1.00	1.00	NA	NA	NA	14.50	6.70	2.16	NA	1.00	1.70	NA	2.70	4.30	2.00
755	26.70	15.30	1.75	2.00	0.90	1.00	3.30	0.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
755	26.90	15.50	1.74	1.00	1.00	1.00	3.80	0.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
755	25.70	16.10	1.60	1.00	0.90	1.00	4.40	0.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
755	27.80	14.70	1.89	1.00	0.70	1.00	4.00	0.00	12.80	5.60	2.29	0.00	NA	NA	NA	1.90	5.30	2.00
755	25.20	15.90	1.58	1.00	0.70	1.00	3.80	0.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
755	25.20	15.60	1.62	1.00	0.80	NA	NA	NA	14.50	6.90	2.10	2.00	1.00	1.80	0.00	NA	5.60	2.00
755	26.00	15.20	1.71	1.00	0.90	1.00	3.50	NA	14.50	6.70	2.16	NA	NA	NA	NA	2.50	4.30	2.00
755	25.00	13.90	1.80	1.00	0.70	1.00	3.80	4.60	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
755	25.70	14.30	1.80	1.00	0.80	1.00	3.70	4.50	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
755	27.60	16.20	1.70	1.00	1.00	1.00	4.90	4.40	14.50	6.70	2.16	2.00	1.00	1.60	NA	3.20	4.40	2.00
756	20.00	14.50	1.38	1.00	1.00	1.00	3.80	0.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
756	22.30	15.60	1.43	1.00	1.00	1.00	4.00	0.00	12.30	6.30	1.95	NA	1.00	1.40	NA	1.40	5.10	2.00
756	23.10	16.20	1.43	1.00	0.80	NA	NA	0.00	8.20	5.30	1.55	NA	NA	NA	NA	NA	NA	NA

756	23.20	16.90	1.37	1.00	0.80	1.00	4.40	0.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
756	23.30	17.50	1.33	1.00	1.10	1.00	4.80	0.00	12.00	6.50	1.85	NA	NA	NA	NA	NA	NA	NA
756	23.50	17.40	1.35	1.00	0.90	1.00	4.10	0.00	14.30	6.30	2.27	1.00	1.00	1.70	0.00	2.70	4.90	2.00
756	23.50	16.70	1.41	1.00	1.00	1.00	4.50	0.00	13.90	7.10	1.96	NA	NA	0.00	NA	3.00	4.00	2.00
756	23.50	15.60	1.51	1.00	0.90	NA	NA	0.00	14.00	5.70	2.46	NA	NA	NA	NA	NA	4.80	2.00
756	23.70	15.10	1.57	1.00	0.90	1.00	3.30	0.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
756	23.90	16.30	1.47	1.00	1.00	1.00	4.40	0.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
756	24.10	15.50	1.55	1.00	0.90	NA	NA	0.00	14.50	6.60	2.20	NA	1.00	1.40	NA	2.40	5.20	2.00
756	24.20	17.40	1.39	1.00	0.90	NA	NA	0.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
756	24.20	15.80	1.53	1.00	0.90	1.00	4.00	0.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
756	24.30	17.30	1.40	1.00	1.00	1.00	3.00	0.00	10.60	6.00	1.77	NA	NA	NA	NA	NA	NA	NA
756	24.30	16.50	1.47	1.00	0.80	1.00	3.60	0.00	14.80	7.70	1.92	1.00	1.00	1.30	0.00	2.20	6.20	2.00
756	24.40	16.60	1.47	1.00	1.00	1.00	3.70	0.00	13.70	7.60	1.80	NA	NA	NA	NA	NA	NA	NA
756	24.70	16.60	1.49	1.00	0.80	1.00	4.20	0.00	12.00	5.70	2.11	NA	NA	NA	NA	NA	4.50	2.00
756	25.10	19.30	1.30	1.00	1.10	1.00	5.00	0.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
756	25.20	17.90	1.41	1.00	0.90	1.00	4.70	0.00	6.60	5.60	1.18	NA	NA	NA	NA	NA	NA	NA
756	26.00	16.50	1.58	NA	NA	1.00	3.60	0.00	13.50	6.20	2.18	NA	1.00	1.50	NA	NA	4.10	2.00
756	27.40	17.40	1.57	1.00	1.00	1.00	4.00	0.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
756	21.10	15.80	1.34	1.00	1.10	1.00	3.40	0.00	10.50	6.80	1.54	NA	NA	NA	NA	2.70	3.90	2.00
756	24.10	15.80	1.53	1.00	1.20	1.00	3.90	3.30	13.10	6.70	1.96	2.00	1.00	1.30	NA	2.50	4.60	2.00
756	23.87	16.53	1.45	1.00	0.95	1.00	4.02	0.14	12.27	6.41	1.91	1.33	1.00	1.23	0.00	2.41	4.73	2.00

756	41.70	25.80	1.62	1.00	2.50	1.00	5.10	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
756	43.40	25.70	1.69	1.00	1.90	1.00	4.90	4.10	16.60	10.00	1.66	NA	NA	NA	NA	NA	NA	NA
756	43.80	26.10	1.68	NA	NA	1.00	3.90	NA	17.80	8.30	2.14	NA	0.00	NA	NA	3.80	6.00	2.00
756	45.10	26.20	1.72	NA	NA	1.00	5.10	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
756	43.50	24.70	1.76	1.00	1.10	1.00	5.20	NA	20.10	9.50	2.12	NA	NA	NA	NA	4.30	7.60	2.00
756	43.50	25.70	1.69	1.00	1.83	1.00	4.84	4.10	18.17	9.27	1.97	#DIV/0!	0.00	#DIV/0!	#DIV/0!	4.05	6.80	2.00
756	27.40	16.40	1.67	1.00	1.20	1.00	3.80	NA	12.80	6.00	2.13	NA	NA	NA	NA	NA	NA	NA
757	24.90	16.90	1.47	1.00	0.90	1.00	3.50	0.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
757	25.30	17.20	1.47	NA	NA	1.00	3.60	0.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
757	25.30	15.60	1.62	1.00	0.80	1.00	3.30	0.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
757	26.20	16.10	1.63	1.00	1.00	1.00	3.70	0.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
757	26.40	17.40	1.52	1.00	0.90	1.00	4.00	0.00	15.00	7.00	2.14	2.00	NA	NA	NA	NA	5.60	2.00
757	26.90	14.30	1.88	1.00	0.80	1.00	3.40	0.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
757	27.50	15.40	1.79	1.00	0.90	1.00	4.10	0.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
757	27.60	15.40	1.79	1.00	0.90	1.00	4.60	0.00	13.70	6.20	2.21	NA	1.00	1.90	NA	NA	5.20	2.00
757	28.00	18.20	1.54	1.00	0.90	1.00	4.60	0.00	13.80	6.50	2.12	NA	1.00	1.70	NA	NA	4.10	2.00
757	28.10	18.00	1.56	1.00	1.10	1.00	4.10	0.00	14.40	6.40	2.25	1.00	NA	NA	NA	NA	5.10	2.00
757	29.70	15.20	1.95	NA	NA	1.00	3.60	0.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
757	30.50	18.80	1.62	1.00	0.90	NA	NA	0.00	16.20	7.90	2.05	1.00	1.00	2.10	0.00	0.00	5.70	2.00
757	31.30	17.70	1.77	1.00	0.90	1.00	4.70	0.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
757	27.52	16.63	1.66	1.00	0.91	1.00	3.93	0.00	14.62	6.80	2.16	1.33	1.00	1.90	0.00	0.00	5.14	2.00

757.00	27.60	15.20	1.82	1.00	0.70	1.00	3.70	NA	11.70	7.60	1.54	1.00	0.00	NA	2.40	3.50	4.70	1.00
TM	26.40	14.30	1.85	1.00	1.00	4.50	NA	0.00	14.50	6.10	2.38	1.00	0.00	NA	0.00	2.40	4.30	2.00
TM	26.60	13.90	1.91	1.00	1.00	1.00	3.10	0.00	14.10	6.30	2.24	1.00	NA	NA	NA	NA	4.90	2.00
TM	27.30	15.10	1.81	NA	NA	1.00	4.40	0.00	14.70	6.30	2.33	2.00	1.00	1.40	NA	3.30	4.50	2.00
TM	27.50	16.20	1.70	1.00	1.00	1.00	4.80	0.00	15.70	6.30	2.49	NA	NA	NA	NA	NA	4.70	2.00
TM	27.60	14.70	1.88	NA	NA	1.00	3.40	0.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TM	27.70	15.20	1.82	1.00	0.90	1.00	3.20	0.00	15.50	6.20	2.50	NA	1.00	1.40	0.00	3.10	4.60	2.00
TM	27.90	14.20	1.96	1.00	0.90	1.00	4.80	0.00	15.10	5.90	2.56	2.00	NA	NA	NA	NA	4.20	2.00
TM	28.00	14.50	1.93	1.00	0.70	1.00	4.30	0.00	15.20	6.10	2.49	2.00	1.00	1.80	NA	NA	4.50	2.00
TM	28.30	15.20	1.86	1.00	1.10	1.00	4.30	0.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TM	28.70	16.00	1.79	1.00	1.00	1.00	4.00	0.00	15.10	6.10	2.48	2.00	1.00	1.30	NA	NA	5.60	2.00
TM	28.80	15.40	1.87	1.00	1.00	1.00	4.50	0.00	15.00	7.30	2.05	NA	NA	NA	NA	NA	NA	NA
TM	24.90	13.00	1.92	1.00	1.00	1.00	4.00	NA	14.50	6.40	2.27	2.00	NA	NA	NA	NA	NA	NA
TM	27.71	14.97	1.85	1.00	0.96	1.32	4.08	0.00	14.99	6.29	2.39	1.67	0.80	1.48	0.00	2.93	4.66	2.00
TM	29.00	14.40	2.01	1.00	1.20	1.00	3.10	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TM	29.50	16.00	1.84	1.00	1.10	NA	NA	NA	14.60	5.60	2.61	NA	NA	NA	NA	2.80	4.70	2.00
TM	29.50	15.50	1.90	1.00	0.90	1.00	4.40	NA	15.10	5.80	2.60	1.00	1.00	1.20	NA	NA	4.50	2.00
TM	29.70	15.30	1.94	NA	NA	1.00	4.20	NA	15.80	6.60	2.39	NA	NA	NA	NA	NA	4.80	2.00
TM	29.70	15.30	1.94	1.00	1.20	1.00	4.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TM	29.80	14.40	2.07	NA	NA	1.00	4.60	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TM	30.30	15.40	1.97	1.00	1.00	1.00	3.40	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

TM	30.50	15.10	2.02	1.00	1.00	1.00	4.30	NA	15.70	6.10	2.57	NA	NA	NA	NA	NA	4.80	2.00
TM	30.90	16.30	1.90	1.00	1.10	1.00	4.60	NA	15.10	6.80	2.22	2.00	NA	NA	NA	2.50	5.20	2.00
TM	31.00	16.20	1.91	1.00	0.90	3.20	NA	NA	14.90	6.10	2.44	1.00	NA	NA	NA	3.80	4.00	2.00
TM	31.20	14.40	2.17	1.00	1.00	1.00	3.50	NA	15.40	6.30	2.44	1.00	NA	NA	NA	3.00	4.70	2.00
TM	32.10	15.30	2.10	1.00	1.00	1.00	4.80	NA	16.20	6.70	2.42	NA	1.00	1.50	NA	NA	4.40	2.00
TM	32.70	15.50	2.11	1.00	1.00	1.00	4.70	NA	17.10	7.20	2.38	NA	NA	NA	NA	NA	5.90	2.00
TM	33.00	14.60	2.26	1.00	1.10	1.00	3.60	NA	15.50	6.70	2.31	2.00	NA	NA	NA	2.70	5.50	2.00
TM	34.00	15.70	2.17	1.00	0.90	1.00	4.20	NA	15.20	6.30	2.41	NA	NA	NA	NA	NA	NA	NA

Samantha Mello
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EDUCATION

State University of New York College of Environmental Science and Forestry, Syracuse, NY
Master of Science in Environmental and Forest Biology, May 2018, GPA: 3.9
Concentration in Fish & Wildlife Biology & Management
Project: Studying ecto- and endoparasite species composition and relative abundance of the New England and eastern cottontails in New York through live-trapping of cottontails; determining ectoparasite trends and ectoparasite composition and abundance of cottontail sites through the use of tick drags; comparing genetic analysis of endoparasites to morphological characteristics to determine species sequencing; genetically exploring the presence of tick-borne pathogens in cottontail populations

Relevant coursework:
- Introduction to R
- Parasitology
- Regression Analysis
- Statistical Sampling Methods
- ANOVA
- Introduction to WinBUGS

University of Connecticut, Storrs, CT
Bachelor of Science in Environmental Science, Honor's Program, May 2014, GPA: 3.4
Concentration in Natural Resources, Dean's List
Honor's Thesis: The Success of Hand-Rearing Rhinoceros Calves

Nature Guide Training, Djuma Game Reserve, Sabi Sands, South Africa, 2014
African Ecology, Cyber Tracker Level II, Reptile/Amphibian handling certificate, CPR and First Aid Certification

University of Wollongong, Wollongong, New South Wales, Australia, 2013
Study Abroad Participant: Effects of Flower Attributes on Hymenoptera

Skills
- **Data analysis:** R, WinBugs
- **Data/Sample Collection:** Qualitative and quantitative study design; field sampling and record keeping**;** mammal trapping; telemetry and homing
- **Data management/Processing:** Microsoft Office 2010 Suite
- **Presentation:** Data graphics (R and Excel), poster and Power point composition, public speaking
- **Lab**: Sterile techniques, fecal floats, microscopy

Professional Affiliations
- The Wildlife Society
- The American Society of Mammalogists

Grants/Awards

OIGS Graduate Student Travel Grant to attend NEAFWA conference in Burlington, VT. **SUNY-ESF.** $200.00. February 2018.

GSA Travel Grant to attend ASM conference in Portland. **SUNY-ESF.** $250.00. April 2017.

ESF Alumni Memorial scholarship to attend ASM conference in Portland. **SUNY-ESF.** $1,200.00. March 2017.

Presentations

Presenter [Oral]. April 2018. The 74^{th} Annual Northeast Fish & Wildlife Conference, Burlington, VT. A Survey of the Parasites of Native and Introduced Cottontails and Their Habitat in the Lower Hudson Valley. **Mello, S**, Cohen, J., Whipps C.

Presenter [Oral]. March 2018. The Wildlife Society New York Chapter Annual Meeting, Kingston, NY. A Survey of Native New England and Introduced Cottontails and their Habitat in the Lower Hudson Valley. **Mello, S**, Cohen, J., Whipps C.

Presenter [Oral]. January 2018. The NEC Technical Committee Annual Meeting, Dover, NH. The Parasite Diversity of New England Cottontails and their Habitat when Non-native Species are Present. **Mello, S**, Cohen, J., Whipps C.

Presenter [Oral]. September 2017. The Wildlife Society Annual Conference, Albuquerque, NM. A Survey of the Parasites of the Native New England Cottontail, the Introduced Eastern Cottontail and Cottontail Habitat in the Lower Hudson Valley.
Mello, S, Cohen, J., Whipps C.

Presenter [Oral]. June 2017. The 97^{th} Annual Meeting of American Society of Mammalogists, Portland, OR. The ectoparasite diversity of New England cottontails (*Sylvilagus transitionalis*) and habitat when non-native species are present. **Mello, S**, Cohen, J., Whipps C.

Presenter [Poster]. June 2016. The 96^{th} Annual Meeting of American Society of Mammalogists, Minneapolis, MN. Parasite mediated competition between the New England and eastern cottontail. **Mello, S**, Cohen, J., Whipps C.

Presenter [Oral]. January 2016. The New England Cottontail Technical Committee Meeting, Kingston, RI. Habitat use, home range, and inter-annual trapping trends of New England cottontails in the presence of a non-native competitor. **Cheeseman, A**, Cohen, J., Whipps C, Ryan, S.

Presenter [Oral]. June 2015. Invasive species, eastern cottontails, and an altered landscape; recovery challenges facing New York’s native New England cottontail. The Black Rock Forest/Highlands Research Symposium, Cornwall, NY. **Cheeseman, A**, Cohen, J., Whipps C, Ryan, S.

Work Experience

Graduate Teaching Assistant: Applied Wildlife Techniques, General Biology I, 2017-2018
SUNY-ESF, Syracuse, NY

- Led weekly workshops covering class material; tutored students on difficult concepts
- Managed curriculum and instruction for weekly lab session; lead labs utilizing a variety of software used in wildlife science; graded all exams; supervised four undergraduate TAs
- Taught scientific writing and data analysis techniques

Subject Tutor, 2018
Huntington Learning Center, Fayetteville, NY

- Taught students ages six to 17 science and math related subjects
- Worked with students one on one and in group settings to help them understand topics they were struggling with

New England Cottontail Research Analyst, **2015**
Research Foundation SUNY-ESF, Carmel, NY

- Acted as liaison between field techs and project head to ensure completion of weekly tasks
- Discussed with the public the purpose of the research and different management directives
- Collected parasites, DNA, blood samples and biological data from cottontails
- Utilized radio telemetry to identify location of cottontail individuals to determine home range and mortality

Seasonal Research Assistant: New England Cottontail Project, 2014-2015
Department of Energy and Environmental Protection Wildlife Division, Franklin, CT

- Implemented management plans designed to promote cottontail habitat on public and private properties
- Discussed property usage and New England Cottontail population with the public to encourage public involvement
- Utilized radio telemetry to identify location of cottontail individuals
- Used handheld GPS units and ArcGIS products to log individual captures

Administrative Assistant, **2012-2014**
Residence Education, University of Connecticut, Storrs, CT

- Coordinated meetings with members of residence life and administrative staff
- Collaborated with team members, provided administrative support within busy office and prepared spreadsheets.

Employee, Shift leader, 2008-2010, 2011-2013
Dunkin Donuts, Somerset, MA

- Assisted the Store Manager in the interviewing, hiring, training, and maintaining records of all new employees using approved HR guidelines
- Monitored performance and customer service of employees
- Managed the sales floor during peak hours of operation to ensure courteous, accurate and efficient service

Camp Counselor and Barn Manager, 2009-2012
Stony Creek Farm, Swansea, MA

- Coordinated activities and schedules for 15-20 children such as riding lessons, lunch, swimming, and hiking trips
- Delegated tasks to assistant counselors and supervised them while they instructed students

Course Experience

Field Mammalogy, University of Connecticut, Storrs, CT, 2014

- Compared small mammal population at edge, forest and riparian habitats using Tomahawk and Sherman traps
- Utilized camera traps to analyze the activity of herbivores and carnivores at edge and forest habitats
- Set leg snares and box traps for black bears

Wildlife Management, University of Connecticut, Storrs, CT, 2014

- Constructed management plan for deer population on private property using wildlife surveys and HSI
- Created a wildlife resource inventory to construct a management plan of the property
- Applied knowledge of GIS tools (GPS, ArcMap and ArcCatalog) to log wildlife sightings and map property structures

Natural Resources Planning and Management, University of Connecticut, Storrs, CT, 2014

- Assessed pileated woodpecker and barred owl population at Campbell Peaceful Valley Conservation Area
- Created a wildlife resource inventory to construct a management plan of the property

Activities and Volunteer

Assistant weightlifting coach, 2016-2018
Recreational Weightlifting Team, Syracuse, NY

- Collaborate with head coach to design a training plan for team
- Educate women on proper lifting techniques while promoting healthy body image and self-esteem

Secretary and Social activities committee member, 2015-2017
Graduate Student Association, Syracuse, NY

Organize events and activities for the graduate student population at SUNY ESF while working autonomously and in a group

Member of Executive Board, 2010-2014
Alpha Beta Epsilon (Academic biology fraternity), University of Connecticut, Storrs, CT

- Made major fraternity decisions affection the organization
- Recruitment leader of academic biology fraternity organizing events for new members
- Organized events and activities for approximately 60 members during social and homecoming positions

Volunteer and Judge, Central New York Science & Engineering Fair, Syracuse, NY, 2017
Player, Syracuse University Women's Rugby Football Club, Syracuse, NY, 2015-2017
Volunteer and Judge, West Genesee Middle School Science Fair, Camillus, NY, 2017